



PHD

The carbon saving potential of community renewable energy in the UK

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THE CARBON SAVING POTENTIAL OF COMMUNITY RENEWABLE ENERGY IN THE UK

Maddy Stow

A thesis submitted for the degree of Doctor of Philosophy

University of Bath
Department of Mechanical Engineering
February 2015

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ABSTRACT

This research answers the question: what is the potential of community renewable energy projects to reduce carbon emissions in the United Kingdom (UK)? This research provides evidence of the benefits of community energy projects in the UK that have been identified as lacking in a recent report produced for the Department of Energy and Climate Change.

The work is based on analysis of primary data collected from 13 community energy projects that were active in 2011 in England and Wales. The 13 projects were based around energy generation and cover three types of technology: photovoltaic (PV), wind turbine and hydro power.

A qualitative assessment is carried out of interviews conducted with representatives of the community energy projects to examine why certain actions are taken during the development and delivery of the projects.

Life cycle assessment (LCA) methodology is applied to these case studies to calculate their carbon impact in three areas: directly through installation of the project; indirectly through use of the income stream created by the project; and indirectly due to behaviour change in the community caused by increased knowledge and/or acceptance of energy generation and climate change issues. The LCA results are then used to model the potential impact of the community energy projects that have already been installed in the UK.

The results of the work suggest that community energy projects do generally reduce carbon emissions in the UK. However use of the income stream typically reduces the potential for the community energy project to reduce carbon emissions. Behaviour change in households to install additional energy generation can increase the potential for the community energy project to reduce carbon emissions. The impact, both positive and negative that government policy has had on the sector is significant despite the perceived independent nature of the sector.

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GLOSSARY

AD	Anaerobic digestion
ASHP	Air Source Heat Pumps
CERT	Carbon Emission Reduction Target
CHP	Combined heat and power
Carbon, Carbon dioxide, CO₂	Carbon dioxide
CCL	Climate Change Levy
CIC	Community Interest Company
CLG	Department of Communities and Local Government
DECC	Department of Energy and Climate Change
DEFRA	Department for Environment, Food and Rural Affairs
DTI	Department of Trade and Industry
EST	Energy Saving Trust
EPC	Energy Performance Certificate
FIT	Feed-in tariff
GHG	Greenhouse gases: water, carbon dioxide, methane, nitrous oxide and fluorinated gases
GWP	Global warming potential, 100 year life time is used in this research
HMG	Her Majesty's Government
ID	Identification
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IPS	Industrial and Provident Society
LCA	Life Cycle Assessment
LCCC	Low Carbon Communities Challenge
LEAF	Local Energy Assessment Fund
LEC	Climate Change Levy Exemption Certificates
LLSOA	Lower Layer Super Output Area
KGCO₂eq	Unit measuring greenhouse gas emissions as the equivalent of carbon dioxide
kW, kWp	Installed capacity of renewable energy
kWh	Unit of energy representing one kilowatt of power used in one hour
OFGEM	Office of Gas and Electricity Markets an independent National Regulatory Authority

PV	Photovoltaic system
RCEF	Rural Community Energy Fund
RHI	Renewable Heat Incentive
RPI	Retail Price Index
ROC	Renewable Obligation Certificate
SAP	Standard Assessment Procedure
UCEF	Urban Community Energy Fund
WRI	World Resources Institute

CHAPTER 1 INTRODUCTION

This chapter outlines the background to the research, aims and objectives and the way in which the thesis has been structured.

This research aims to answer the question: what is the potential of community renewable energy projects to reduce carbon emissions in the United Kingdom (UK)?

1.1 Background

Around the UK there are a growing number of communities that are coming together to generate, reduce, manage or purchase energy (DECC, 2014f). The current focus of many of these community energy projects is the installation of renewable generation, particularly solar photovoltaic systems (PV) and onshore wind (DECC, 2014f).

The Climate Change Act sets out a target to reduce carbon emissions 80% by 2050 compared to the baseline year, 1990 (HMG, 2008). Although there are a wide range of benefits ascribed to community energy projects, reducing carbon emissions is the main motivation for most communities to undertake such a project (DECC, 2014e).

There is evidence that renewable energy projects save carbon emissions - savings can be predicted from the size of the system (DECC, 2014e). However lifecycle carbon emissions from such systems are not insignificant and should be included during evaluation (Varun et al., 2009). Lifecycle carbon emissions are often not captured during evaluation of community renewable energy projects, for example Energy Share (2012). This website contained case studies of community renewable energy projects showing their carbon impact, but lifecycle emissions were not included.

Unlike other scales of energy projects, community energy projects have a potential to affect carbon emissions beyond those directly targeted by the project (DECC, 2014f). Income generated by projects can be used to further reduce carbon emissions in the community, for example through installing energy efficiency measures or providing energy advice services (DECC, 2014f). Energy and climate change awareness and therefore engagement with these issues may increase within the community, further reducing carbon emissions (DECC, 2013b).

There is limited empirical evidence with regards to the impact of community energy projects (Databuild Research & Solutions Ltd, 2013). However communities are considered to be at the heart of meeting the UK's climate change challenges (DECC, 2014f). Various UK policies have been designed to support these community groups get access to funding (Devine-Wright et al., 2007), for example the feed-in tariff (EST, 2011) and the Urban Community Energy Fund (DECC, 2014j). Therefore there is an urgent need to assess the actual extent of carbon savings from community energy projects in the UK.

This research assesses the carbon savings of community renewable energy projects using life cycle assessment (LCA) methodology applied to ongoing projects in the UK. It assesses the impact of

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three aspects of community energy projects: the initial project, income from the project and energy behaviour in the community.

1.2 Aims and objectives

In order that the potential of community renewable energy projects to reduce carbon emissions from the UK should be explored, to aid communities, funding bodies and policy makers to make informed decisions about the future of community energy, the aims of this research are:

- Aim 1:** To assess the net carbon emissions that are attributable to community energy projects in the UK and identify factors that have influenced this potential
- Aim 2:** To assess the effect that uptake of community renewable energy will have on carbon emissions from the UK

The following objectives were defined to meet these aims:

- Objective 1:** Recruit and collect data from community energy groups that have installed or are planning to install renewable energy generation as part of a community energy project
- Objective 2:** Explore why community energy groups take certain courses of action during delivery of a community energy project
- Objective 3:** Investigate the extent to which decisions during project development have affected the carbon footprint of the project
- Objective 4:** Investigate the potential carbon emission impact due to the income generated by the community energy project
- Objective 5:** Investigate the extent that community energy projects influence energy use and installation of renewable energy systems by households within the community
- Objective 6:** Calculate the carbon footprint of the recruited community energy projects, including the wider carbon emissions attributable to the project, using life cycle assessment (LCA) methodology
- Objective 7:** Compare carbon footprints of different community energy projects and evaluate the range of outcomes
- Objective 8:** Compare carbon footprints produced using LCA methodology with those produced using current methodology, which focus on the generation phase only, to assess the validity of the current methodology as a basis for policy creation
- Objective 9:** Examine the growth of community energy in the UK and the effect this will have on carbon emissions from the UK

1.3 Thesis structure

Figure 1-1 illustrates the structure of the thesis mapped against the objectives set out above. Chapter 2 contains a review of the relevant literature to set the scene and to illustrate where the current gaps in knowledge are that this research fills. The methodologies used in this work are reported in Chapter 3. Chapters 4 to 9 meet Aim 1. Aim 2 is met in Chapter 10.

Chapter 4 provides a comparison of the sample of community energy groups that participated in this research against a profile of the sector compiled for the Department of Energy and Climate Change to demonstrate the validity of applying the results of the sample to the sector. A case study introduction to each community energy group that was interviewed is also presented. This chapter shows how objective 1 is met.

A qualitative analysis of interviews carried out with the community energy groups is presented in Chapter 5. This chapter meets objective 2, to examine why certain courses of action are taken during delivery of a community energy project. This chapter provides the models presented in later chapters with a realistic basis.

Chapter 6 investigates the extent to which decisions during project development, identified in Chapter 5 have affected the carbon footprint of the direct emissions from the project using LCA methodology. It also presents the carbon impact of the project for each of the case study groups. This meets objective 3.

The results of an analysis of the carbon impact of the income stream are presented in Chapter 7, meeting objective 4. Analysis is presented for each case study and is shown in terms of spending and in the carbon impact of this spending. The carbon impact of spending is calculated using life cycle inventory data and input-output data.

Objective 5, to investigate the effect that community energy projects have on two types of energy behaviour is met in Chapter 8. This chapter presents the results of statistical analyses of a national dataset and data collected by one of the participating community energy groups.

The results of Chapters 6 to 8 are combined in Chapter 9 to form a carbon footprint for each community energy project, which is calculated using LCA methodology. This meets objective 6. These footprints are then compared to meet objective 7. Finally in this chapter the carbon footprints are compared with those calculated using current methodology to meet objective 8.

Chapter 10 presents the results of analysis to examine the recent growth of community energy projects. The basis for this analysis is the central feed-in tariff database. This chapter meets objective 9.

A discussion of the work and its limitations is presented in Chapter 11. Finally the key findings of this research are presented in Chapter 12 and are placed in context of their contribution to the field.

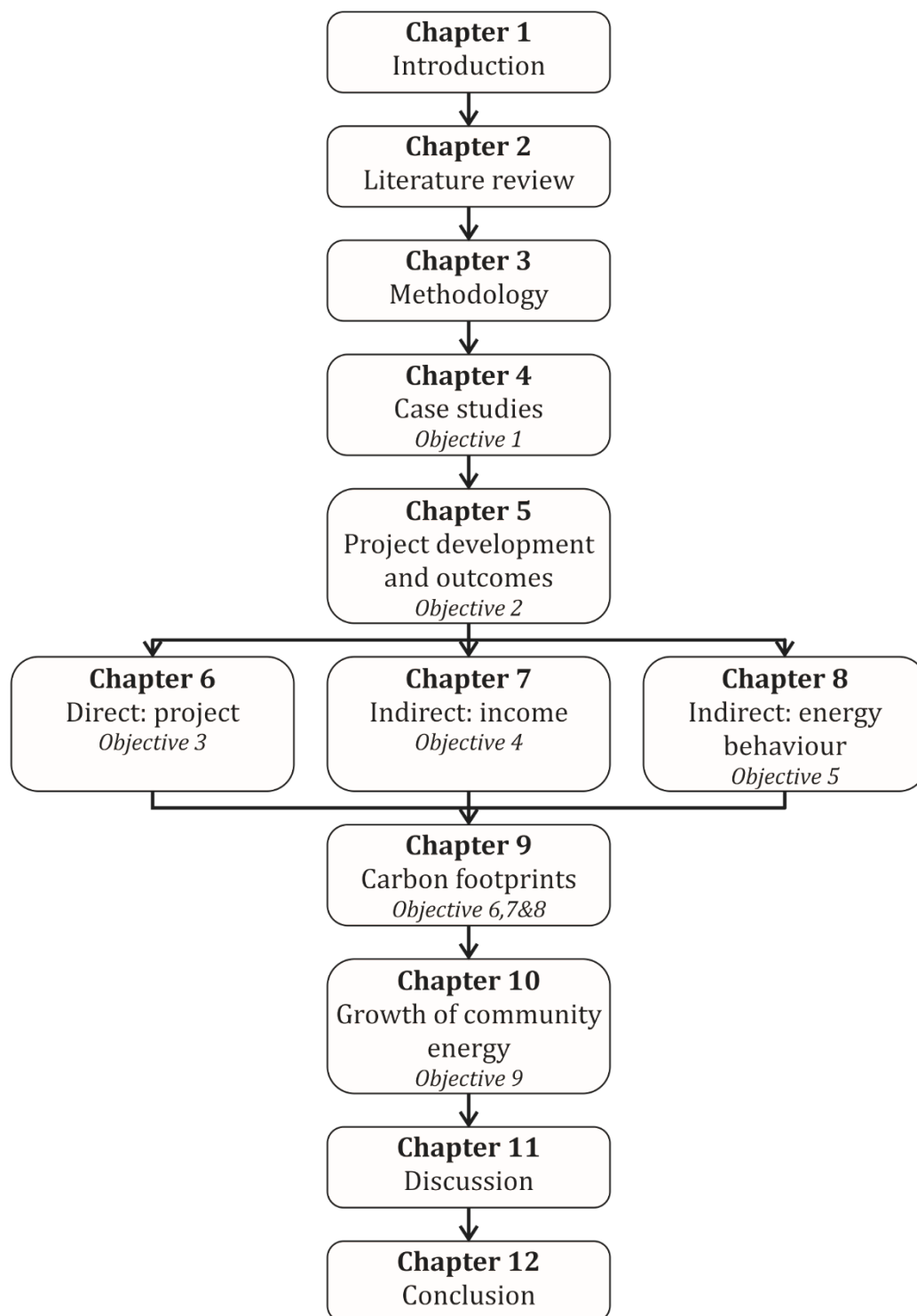


FIGURE 1-1 STRUCTURE OF THESIS

CHAPTER 2 LITERATURE REVIEW

This chapter sets the scene for research of the potential for community energy projects to help meet the UK climate change target, by presenting a literature review. It is split into four sections. The first section explores the need for climate change targets and the role of the energy sector in meeting the UK's targets. The second section establishes a definition of community energy projects in the UK. It then focuses on the development of community energy, both in the UK and abroad, developing themes essential to understanding community energy. In the third section current evidence for the carbon saving potential of community energy projects is evaluated and the gaps in current knowledge this research aims to fill are identified. The final section explores methodologies for carbon accounting in order to fill this gap in knowledge.

2.1 Background

Community energy is a young, rapidly growing sector in the UK (DECC, 2014e). Governments, focused on achieving large-scale energy transitions are introducing policy to support community energy (Hielscher et al., 2013). The British Government is amongst those looking to achieve an energy transition to meet their carbon target (HMG, 2010): the Climate Change Act (2008) sets out a legally binding 80% reduction in carbon emissions by 2050 from baseline levels in 1990 (HMG, 2008).

The £10 million Low Carbon Communities Challenge (LCCC) was launched in 2010 and ran for two years as a test programme to monitor and evaluate community-scale energy projects (DECC, 2012d). The British Government stated that it was “unambiguous in its commitment to encouraging community-based ownership of renewable energy” in its 2011 Microgeneration Strategy (DECC, 2011e). In December 2011 the Local Energy Assessment Fund (LEAF) was launched by the Government; a onetime £10 million fund to help communities develop energy projects (DECC, 2011a). The Community Energy Efficiency Outreach Programme was carried out in 2012 to evaluate the effectiveness of community engagement initiatives (DECC, 2014i). A call for evidence for Community Energy was published in June 2013 by DECC (2013b). The Community Energy Contact Group was established by DECC, comprised of members active in community energy in the UK, to advise on policy design and impact and identify barriers and solutions for community energy (DECC, 2014d).

In January 2014, Britain's first Community Energy Strategy was published (DECC, 2014f). The strategy set out that a Community Energy Unit would be created to lead the Department of Energy and Climate Change policy on community energy (DECC, 2014f). The Community Energy Unit launched the £15 million Rural Community Energy Fund (RCEF) and are planning a £10 million Urban Community Energy Fund (UCEF) (DECC, 2014c).

The British Government appear supportive of community energy; communities are considered to be at the heart of meeting the UKs climate change challenges (DECC, 2014f). However there is limited empirical evidence of the impacts of community energy projects (Databuild Research &

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Solutions Ltd, 2013). There is a need to quantify impacts with more robust evaluation of project outcomes; previous research has focused on evaluation of project processes (Walker and Stanford, 2014). This necessitates the question: What is the evidence that community renewable energy projects will help the UK meet its climate change target?

2.2 Climate change target

Evidence from a wide range of sources indicates it is very likely that recent increases in global average temperature can be attributed to greenhouse emissions due to human activity (IPCC et al., 2007, The Royal Society, 2010). The negative consequences of this rise in temperature are likely to far outweigh any positive consequences (IPCC et al., 2007).

Water vapour, carbon dioxide, methane, nitrous oxide and fluorinated gases are all classed as greenhouse gases (GHG): they have a warming influence on the atmosphere. Of these carbon dioxide is considered to be the most important as it is responsible for the largest contribution towards the greenhouse gas effect of the anthropogenic GHG (The Royal Society, 2010, IPCC et al., 2007).

The influence that each GHG has on warming the atmosphere is different. The Global Warming Potential (GWP) of each GHG is a measure of how much warming that GHG would cause in comparison to that which would be caused due to the emission of an equal amount of carbon dioxide. It is affected by the timescale over which the impact is to be considered. The GWP can be used to convert GHG emissions into CO₂ equivalent emissions, which is often used as the metric for reporting GHG emissions (IPCC et al., 2007). Large scale reductions of GHG will be needed to limit climate change (IPCC, 2013).

The government recognises the need to reduce carbon emissions: a target of reducing carbon emissions by 60% by 2050, where 1990 is set as the baseline year was introduced in the Energy White Paper 2003 (DTI, 2003). A subsequent report by the Climate Change Committee made the case for the UK to reduce emissions by 80%: advances in climate sciences suggested higher reductions were required and that the UK should aim for globally equitable per capita emissions (Committee on Climate Change, 2008). Following this, a legally binding target to reduce carbon emissions by 80% by 2050 compared to the baseline year, 1990 was included in the Climate Change Act 2008 (HMG, 2008). The carbon target includes: carbon dioxide, nitrous oxide, methane and fluorinated gases (HMG, 2011a). This target includes the GHG that are emitted from the UK, known as territorial emissions. It does not include GHG that are emitted from other countries as a result of activity in the UK, known as consumption emissions – which are rising even as territorial emissions fall (Energy and climate change committee, 2012a). To ensure that this target is met, a series of carbon budgets have been created. Each budget is set for five years and represents the total amount of carbon that can be emitted in the UK during that time: this reduces over time (DECC, 2012a).

The UK also has a target under the Kyoto Protocol to reduce GHG emissions by 12.5% over the first commitment period (2008-2012) to below 682.4 million tonnes of CO₂e (see section 2.7.3 for more on Kyoto Protocol). In 2012, the UK emitted 581.1 MtCO₂e of GHGs measured under the Kyoto Protocol, 82% of which was carbon dioxide (DECC, 2014a).

2.2.1 The energy sector

The energy sector must be almost completely decarbonised if the climate change target is to be met due to the comparative difficulty and cost of decarbonising other sectors, for example agriculture (Committee on Climate Change, 2008, HMG, 2011a). Therefore the energy sector must undergo substantial change to both supply and demand (HMG, 2010).

2.2.1.1 Domestic energy use

In 2012 the domestic sector was responsible for 29% of all energy consumption in the UK (DECC, 2013d). Although there has been a 12% energy consumption reduction per household compared to 1990, an increasing number of households has resulted in a 6% energy consumption increase by the sector (DECC, 2013c). It is predicted that the number of UK households will continue to increase (National Statistics, 2010b, National Statistics, 2010a, Northern Ireland Statistics and Research Agency, 2010, CLG, 2009). In England an extra 252,000 households are projected per year up to 2031 (CLG, 2009).

Domestic consumption is predominantly driven by the temperature as space heating accounts for 66% of it (DECC, 2013c). Electricity consumption for lighting and appliances has increased due to a higher number of appliances that use electricity (Palmer and Cooper, 2011) although this has been offset to some extent by improvements in energy efficiency (DECC, 2013c).

In 2012 the domestic sector accounted for 145.3MtCO₂e of GHG emissions by end-user, this is equivalent to 25% of the total (DECC, 2014b). GHGs have decreased 14% since 1990, mostly due to space heating switching from coal to natural gas, (Hawkes et al., 2011, DECC, 2011f). Space heating (usually natural gas) accounts for a larger proportion of domestic energy use than lighting etc. (electricity) (DECC, 2013c). However emissions from the average electricity supply is around 430 g/kWh, higher than those from natural gas, 390 g/kWh (DECC, 2011b). Consequently the carbon impact of electricity use is higher than would be suggested by its consumption in the domestic sector (Joint working group on energy and the environment, 2005).

Domestic sector energy use will have to decrease if the 2050 target is to be achieved (Palmer and Cooper, 2011). This may only be possible through whole-house efficiency retrofit and installation of microgeneration (Scrase et al., 2009, Boardman, 2011). Scenarios, called pathways, of potential energy systems have been developed to evaluate different transformations which would meet the target (Foxon et al., 2010, HMG, 2010).

2.2.1.2 Energy system pathways

The 2050 Pathways analysis report was published in July 2010, based on evaluation of the 2050 Pathways calculator (DECC, 2013a). This analysis suggests that meeting the target requires heating, transport and industry to be electrified, alongside the decarbonisation of electricity supply and a substantial reduction of per capita energy demand (HMG, 2010). The speed required for such a large scale transition will require participation from citizens, businesses and the energy industry (HMG, 2010).

The concept of different actors having an active role in the energy system transition is reflected in the Transition Pathways to a Low Carbon Economy project. This has three main scenarios: Market Rules, Central Co-ordination and Thousand Flowers (Foxon et al., 2010). The thousand flower pathway is a vision of the energy system influenced by actions made by households, communities and local authorities (Transition Pathways, 2012).

Decarbonisation may be the main driver for energy system transition at the current time (Boston, 2013). However it will be imperative to maintain a supply of affordable, secure energy during the energy system transition (Foxon et al., 2010).

2.2.1.3 Energy Trilemma

Decarbonisation is not the only challenge that energy systems face (DTI, 2007). Access to affordable, reliable energy is considered to be integral to improving conditions in developing countries and to sustaining conditions in developed countries (United Nations Development Programme et al., 2011). These three factors, illustrated in Figure 2-1, are commonly referred to as the sustainable energy trilemma: decarbonisation, energy security and affordable energy (Falkner, 2014).

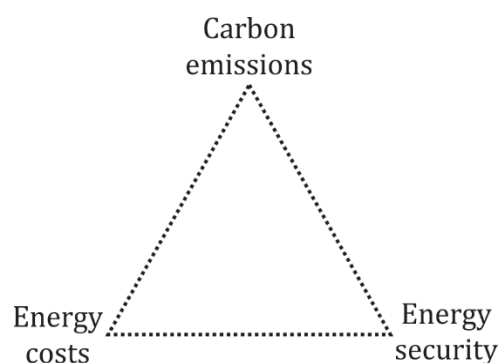


FIGURE 2-1 SUSTAINABLE ENERGY TRILEMMA

Energy security is defined as a reliable supply of energy that meets demand (Energy and Climate Change Committee, 2012b). Affordable energy is important to all sectors, however in 2001 the Government made a commitment to reducing fuel poverty by ensuring every household could be heated affordably (HMG, 2001). Fuel poverty is defined as households which would have to spend more than 10% of their income to achieve satisfactory heating (Boardman, 2010). Households with poor energy efficiency is the primary cause of fuel poverty (Boardman, 2007).

Maintaining the balance between the three factors is key; the factors are sometimes in competition with each other causing the trilemma (Umbach, 2012). For example, in the UK an increased use of coal from national supplies would improve energy security whilst causing an increase in carbon emissions (Gunningham, 2012). However energy security and climate change are often addressed through separate policies (Gunningham, 2012).

This is the current energy landscape into which community energy fits; supporters of community energy have suggested that it addresses the bigger energy picture through a joined up approach, linking supply and demand to the local community (Stow et al., 2014).

2.3 Definition of community energy

The British Government’s definition of community energy is “community projects or initiatives focused on reducing, managing, generating or purchasing energy” (DECC, 2013b). Community ownership or control and the community benefiting are important to these projects (DECC, 2014f). This aligns with work by Walker and Devine-Wright (2008), who identified two key factors to define community energy: process – who develops the project and outcome – who benefits (particularly socially or economically). Figure 2-2 shows how these factors can be used to illustrate the difference between community energy projects and energy projects run by traditional actors (Walker and Devine-Wright, 2008).

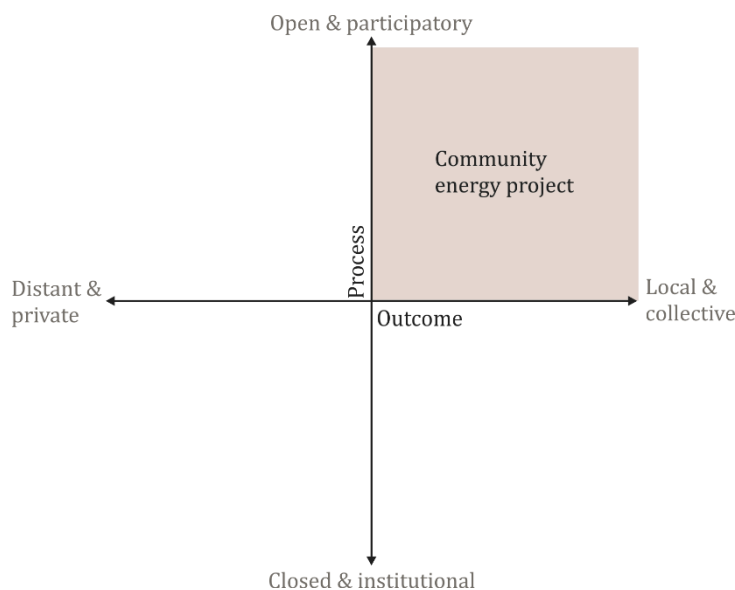


FIGURE 2-2 IDENTIFYING A PROJECT AS COMMUNITY ENERGY (ADAPTED FROM WALKER AND DEVINE-WRIGHT (2008))

Community can refer either to a group living within a geographical boundary - community of place, which is more common or groups linked by a common theme - community of interest (Heiskanen et al., 2010) (DECC, 2014f).

Although local authorities, businesses and housing associations can play a vital part in supporting community energy, the government’s viewpoint is that to include these bodies within the definition would blur the distinction between community energy and local energy (DECC, 2014f).

Community energy could spark the changes required to address current energy challenges by sharing benefits and encouraging participation in communities (Capener, 2014).

2.4 Potential benefits of community energy

The benefits that it has been claimed community energy can provide are wide ranging, including environmental, energy, economic and social (DECC, 2014f).

2.4.1 Environmental

The main motivation to undertake a community energy project is to reduce carbon emissions (DECC, 2014e). This can be achieved by: installing low carbon generation, reducing energy consumption through behaviour change or energy efficiency measures (DECC, 2012c). Most households do not understand the connection between energy use and climate change (Hawkes et al., 2011), this can be addressed through community energy projects (DECC, 2014f). Community energy projects may also affect carbon emissions beyond the energy system, for example, one project charges an electric club car (Talybont on Usk, 2014).

2.4.2 Energy

The centralised energy system in the UK suffers from losses of around 65% of energy input due to: heat wasted during generation, transmission losses and distribution losses (Allen et al., 2008). Transmission losses are losses of electricity, i.e. from resistive losses, from the high voltage transmission system and distribution losses are those on the distribution network (DECC, 2014g). Losses are reduced when energy is generated close to where it is used, (Allen et al., 2008), as is the case with community energy projects.

Community energy projects can raise understanding of energy use in the community which can lead to both reductions in energy consumption and a shift in energy consumption patterns to reduce peak loading, reducing the requirement for generation capacity (DECC, 2014c). They may also increase acceptance of renewable energy, improving both uptake by households and acceptance of large private projects (DECC, 2012d). This has economic and social benefits for the community, for example, local increased demand for energy efficiency measures may create sustainable local jobs providing installation services (Ison and Hicks, 2012).

2.4.3 Economic

Energy generation at a community scale can provide economies of scale (DECC, 2011e). Technology that is expensive for individual households to purchase can be made cheaper through community bulk purchasing schemes creating an economy of scale (Centre for Sustainable Energy, 2014).

Some models of community energy project provide an income stream. Renewable generation projects receive payments under the Government schemes: feed-in tariff (FIT) and renewable heat incentive (RHI) (DECC, 2014f). This income is used by communities in a number of ways: installing energy efficiency, installing renewable generation, community fund and job creation (Walton, 2013).

Shareholders, financial investors who receive interest payments, are the primary beneficiaries of the income stream. However if this money is spent in the community, the whole community can benefit .e.g. keeping local shops open. This is known as the local multiplier effect (Stow et al., 2014).

2.4.4 Social

Social benefits of community energy can include community empowerment, well-being, and social inclusion (New Economics Foundation, 2012). The project can provide a focus for improving the community and bringing people together encourages skill swapping (DECC, 2014f). Social cohesion is improved and may help develop and preserve the community (Walton, 2013). Households in fuel poverty may benefit from community energy through free energy or improving the energy efficiency of households. For example the Meadows Ozone Energy Services (MOZES) project aims to reduce fuel poverty by reducing fuel bills through free electricity to households whilst the FiT income goes to installing more renewable generation in the community (Saunders et al., 2012).

2.5 Worldwide development of community energy and policy

Although community energy is a young sector in the UK (DECC, 2014e), the practice of communities owning and benefiting from the energy system is well established in countries such as Denmark, Sweden and Germany (DECC, 2014f) (DTI, 2005). The definition of community energy varies from country to country and unlike the UK may include municipal authorities or landowners (DECC, 2014f).

2.5.1 Denmark

Prior to the 1970s oil crisis, oil generated around 90% of electricity in Denmark (Meyer, 2004). Following the oil crisis, the Danish Government took measures to improve Denmark's energy security (Carlman, 1988). Oil and natural gas reserves in the Danish North Sea were only found in the mid-1980s (IEA, 2011). The Government, backed by cross party support, focused on renewable energy -unlike other European countries who looked to nuclear energy (Meyer, 2004).

Long term policies, shaped by public participation (Lund et al., 2010), to increase both renewable energy generation (Sperling et al., 2010) and energy efficiency (Lund, 1999), were introduced. Energy demand is at a similar level to pre 1970s (Tonini and Astrup, 2012) despite economic growth (IEA, 2011). This is likely due to a low annual population growth of around 0.4% (The World Bank, 2014) and improvements in energy efficiency. Denmark uses energy very efficiently: a high proportion of energy comes from combined heat and power (CHP) and vehicles have been taxed according to their fuel efficiency since 2000 (IEA, 2011). Building codes have stringent energy efficiency requirements, which apply to both new build and refitting buildings including subsidies for households to replace inefficient oil boilers (IEA, 2011).

Energy prices in Denmark were historically higher than other countries (Carlman, 1988) due to taxation; there are taxes on oil, coal, natural gas, electricity and vehicle fuel etc. (IEA, 2011). However analysis by Lund et al. (2012), suggest that electricity prices are now below average in the EU. The high proportion of variable generation means that a substantial amount of Danish energy is sold at low prices on the Scandinavian Nordpool electricity market (Hvelplund, 2006).

Renewable sources make a major contribution to total energy generation; 20% from wind power and 50% from CHP (Lund et al., 2010). Denmark is well placed to cope with a large amount of variable supply due to connections with Germany and the Nordic market, however this ability has been bolstered by heavy investment in electricity supply infrastructure (IEA, 2011).

Compulsory connection orders were introduced to ensure that district heating would be viable (DTI, 2005). District heating supplied about 60% of Denmark in 2011 (Dalla Rosa and Christensen, 2011). CHP plants are located close to towns and cities as part of a highly distributed energy system (Möller and Lund, 2010). These CHP plants can co-fire biomass, such as straw, which are subject to subsidy schemes (Voytenko and Peck, 2012).

Windmills, the predecessors to wind turbines have a long history in Denmark; 30,000 windmills were operating by the 1930s (DTI, 2005). The Government supported the development and deployment of wind turbines (Meyer, 2004) through grants for production and tax exemptions (IEA,

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2011). This has created an industry which exports globally and by 2005 had 20,000 employees (DTI, 2005). The Danish wind turbine industry scaled up small three bladed turbines to produce more powerful turbines (Meyer, 2007, Nilsson et al., 2004). Turbines are certified at Risø National Laboratory (Meyer, 2004).

Local co-operatives and individuals were reimbursed 30% of the turbine price, grid connection and installation by the Government from 1979 if they installed a certified wind turbine (Meyer, 2004, Carlman, 1988). This was reduced over time and finished in 1989 (Meyer, 2007). Feed-in tariffs were introduced in 1992 (Meyer, 2007).

Prior to 1996, local co-operatives were the primary owners of wind turbines (Hvelplund, 2006); 80% of wind generation was through local co-operatives (Danielsen, 1994) or 3.5% of total energy generation (Hvelplund, 2006). Each co-operative owned two to four wind turbines and was typically formed of 50 to 100 households (Madsen, 1988). There were around 120,000 wind turbine owners prior to 1996 (Hvelplund, 2006). Denmark has a rich history of co-operatives, with examples found in agriculture (Gundelach, 2005) and education (DTI, 2005). Public opinion about these smaller, communally owned wind turbines was generally positive (Meyer, 2007).

Post 1996 private ownership, often farmers, largely replaced co-operative models of ownership, alongside a large increase in installed wind capacity (Hvelplund, 2006). Feed-in tariffs were replaced with the green certificates in 1999 in anticipation of EU regulation which didn't come into being (Meyer, 2004). Green certificates suffered from a string of problems, including high costs and in 2004 still had not been fully introduced (Meyer, 2004). In 2002, a further 1,300 co-operatively owned turbines were replaced with larger, privately owned turbines under a repowering scheme (Meyer, 2004). In 2004 it was estimated that 25,000 fewer households owned shares in a co-operative owned turbine (Meyer, 2004). This decline in the co-operative model has been attributed to less favourable financial support (Morthorst, 1999).

The Danish energy system was liberalised with the Energy Act 2000, following European Union (EU) regulation (Meyer, 2004). Conditions for renewable energy became unfavourable in 2001 with the election of a new Government, when state subsidy schemes for renewable energy were abolished (Hvelplund, 2006, Meyer, 2004, Danish Energy Agency, 2012). Uncertainty caused by policy changes led to a decline of new private ownership of wind turbines (Meyer, 2007). New wind turbine installation, other than large scale projects, had stopped by 2005 (DTI, 2005).

The 2008 Energy Policy agreement improved support for renewable energy (IEA, 2011). Risks during development of wind projects are shared with the government, however interest in development is still low (IEA, 2011). In 2011 the Danish Government set a target of 100% renewable energy system (Kwon and Østergaard, 2012). It has been suggested to achieve this, plans will need to include input from local stakeholders and authorities (Sperling et al., 2011). The International Energy Agency (IEA, 2011) feel that the Energy Strategy 2050, the culmination of over 30 years of energy policy with strong political support, is well thought out, with clear targets and financial support.

2.5.2 Sweden

Sweden has a history of strong regional governance and prior to the gradual introduction of market liberalisation throughout the 1990s municipalities typically ran both electric utilities and district heating (Westholm and Beland Lindahl, 2012). District heating was enabled through government policies to mandate connection to a network were available (DTI, 2005). This has resulted in a highly distributed energy system consisting largely of CHP linked to district heating, which serves local communities and can therefore be referred to as community energy i.e. Rydén et al. (1993). The energy system in Sweden is significantly different to that in the UK, for example there are more links between suppliers and distribution network operators in Sweden than the UK (Pyrko and Darby, 2010).

The Swedish Government have created a relatively stable political environment for renewable energy with a range of energy taxes and a green certificate program requiring purchase of credits from non-fossil fuel production to offset fossil fuel use (Hultman et al., 2012) (DTI, 2005). This combined with support from the Government to promote domestic biomass following the 1970s oil crisis (Westholm and Beland Lindahl, 2012) and the distributed nature of the energy system has paved the way for co-operatives to supply CHP plants with biomass (DTI, 2005). The co-operatives consist of farmers that provide the biomass feedstock, usually willow, to their local CHP plant. The aims of these co-operatives are to provide a source of income for the farmers and to provide a renewable heating source to their communities (DTI, 2005). However the quantity of biomass delivered has been linked to Government subsidies, i.e. when the subsidy was removed the quantity coppiced fell (DTI, 2005), suggesting that the primary aim is the income stream.

2.5.3 Germany

Germany has ambitions of an energy system largely based on renewable energy by 2050 following a phasing out of nuclear power (Lund et al., 2012). Germany already has a high proportion of renewable energy generation and wind cooperatives operate many renewable energy projects (Warren and McFadyen, 2010). With over 3000 MW of wind capacity installed by 1999 (Morthorst, 1999), there is now over 5000MW of wind capacity owned by cooperatives such as “Bürgerwindparks” or “Citizens’ wind farms” (Toke et al., 2008) and in 2010 it was estimated that over 140 new energy cooperatives had recently formed (Weismeier-Sammer and Reiner, 2011). Cooperatives are particularly located in the Northern and Western regions of Germany (Musall and Kuik, 2011) as co-ownership was encouraged at a state rather than federal level (Breukers and Wolsink, 2007).

A number of factors influencing the growth of cooperatively owned energy have been identified: the German cooperative law, active consumers and public participation in energy activism ((Müller and Rommel, 2010) in (Weismeier-Sammer and Reiner, 2011)), the feed-in tariff system and availability of investors (Weismeier-Sammer and Reiner, 2011). The German government funded research and development in the wind sector in the early 1980s. Although this funding was initially aimed at large scale turbines, failure of the first projects in 1985 meant that the remaining funding was split between a larger number of institutions to develop small scale turbines. The German Wind Energy Association, along with other renewable energy organisations successfully lobbied the

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government to introduce the Electricity Feed-in Act in 1991. This act encouraged private investors such as farmers and households to install these small scale wind turbines as they received an income stream and guaranteed access to the grid, thus paving the way for high active public participation in the energy sector (Breukers and Wolsink, 2007). This followed already high public involvement in the anti-nuclear movement prevalent throughout the 1970s and 1980s (Toke et al., 2008)

Despite the high level of renewable energy in Germany, the sector has not had continuous political support especially at the federal level. The legality of the feed-in system was taken to court by the energy sector and the Renewable Energy Sources Act designed to replace the Electricity Feed Act in 2000 was delayed until 2004 due to the feed-in tariff system. This caused uncertainty in the market (Breukers and Wolsink, 2007). Additionally it has been suggested that local renewable energy could be supported further by redesigning the energy market to enable local trading between generators and consumers (Hvelplund, 2006).

2.5.4 Community energy outside the UK

In the three case studies of community energy development in different countries similar factors have been identified as contributing to the development and decline of these projects. Long term Government support for community and renewable energy, typically prior to privatisation of the energy system, enabled this type of project to develop. The energy systems in these countries are typically more distributed than in the UK due to development of district heating through compulsory connection orders. This has meant that power is generated closer to the end users in the domestic sector. Although these countries have historically had a high interest in community energy, this has declined in some. This waning of community energy has been linked to the decline in financial benefits available.

2.5.5 United Kingdom

Historically UK energy policy has been described variously as innovative, more expensive (IEA, 2007), an out of date model and unresponsive (Helm, 2002, Helm, 2008). A lack of a coherent overarching energy policy has led to piecemeal policies, focusing on specific sectors or technologies (Helm, 2008, IEA, 2007).

Following Nigel Lawson's "the market for energy" speech in 1982 and privatisation of the energy system, policy has been used to create a framework for the energy market to deliver cheap energy (Helm, 2008). However markets typically focus on short term gains rather than the long term investment needed to transform the energy system (Lund, 2007, Helm, 2008, Scrase et al., 2009). This behaviour is reinforced by regular policy changes or withdrawal, which creates high risks for long term investments (Hawkes et al., 2011).

2.5.5.1 Demand side reduction

Demand side reduction is believed to be more-cost effective than supply side changes to achieve a low carbon energy system (IEA, 2007, DEFRA, 2006). Over the last decade a number of Government led schemes targeting energy efficiency in households have been introduced (IEA, 2007, HMG,

2011a): Green Deal, Warm Home Discount, Energy Company Obligation, Energy Efficiency Commitment and Carbon Emission Reduction Target (CERT) (HMG, 2014).

Concerns have been raised that these schemes are not delivering their technical potential (Helm, 2003, Hawkes et al., 2011). The CERT was designed to reduce domestic sector carbon emissions, however the onus for achieving the target was placed with energy suppliers and therefore low visibility may have limited the potential for achieving carbon reductions by the public (Ekins et al., 2011). It has been claimed that households do not install energy efficiency measures for a number of reasons. They do not act as rational economic agents, i.e. do not discount future savings against capital outlay (Schipper et al., 1992, Bergman and Eyre, 2011, OXERA, 2006). They will not do it on the basis of carbon reductions (Ramesh, 2011, Verplanken, 2011) and the measures are seen as intrusive and unfamiliar (Saunders et al., 2012). Energy efficiency in households is a complex issue and installation rates are unlikely to increase without intervention (Low Carbon Construction Innovation & Growth team, 2010).

2.5.5.2 Supply side change

Renewable energy should supply 15% of total energy consumed in the UK by 2020 under the 2009 renewable energy directive (European Parliament and Council, 2009). However just 3.3% of energy consumption was met by renewable sources in 2010 (HMG, 2011b).

Renewable and small scale generation were disadvantaged by successive energy trading agreements (Mitchell and Connor, 2004, Helm, 2003, Hawkes et al., 2011, Kelly, 2007). Development of a UK based low-carbon supply chain has been hampered as developers' priorities established overseas supply chains due to the short project time frames introduced by policy (Connor, 2003).

Although demand side reduction may be cost-effective, supply side changes may provide longer term benefits, such as technological innovation and diversity of supply (DEFRA, 2006). Use of renewable sources to supply energy increases the diversity of energy supplies, currently based on fossil fuels, which improves energy security (Asif and Muneer, 2007). Their use can also create jobs (Asif and Muneer, 2007), for example the wind industry in Denmark (DTI, 2005). Furthermore renewable energy systems may have a wider effect, potentially altering consumer behaviour (Pehnt, 2006). Consumers may use more energy, known as the rebound effect (see section 2.6.4) or may become more energy literate and reduce energy consumption: the evidence of these effects is mixed (Pehnt, 2006). However a report by DTI (2005) recommended that the emphasis of policy should be focused on wider community benefits and overcoming barriers to the development of community-owned projects.

2.5.5.3 Support for community energy

Countries with established community energy have enjoyed long term policy support along with a culture of cooperation (DTI, 2005). There has been a shift in energy policy focus; new energy policy is removing barriers to community energy projects (Park, 2012). The sector has grown due to recent policy support (Hielscher et al., 2011).

2.5.5.3.1 Low carbon communities challenge 2010 -2012

The Low carbon communities challenge (LCCC) was a test project between 2010 and 2012 to monitor and evaluate community-scale energy projects (DECC, 2012d). The Government financed around £10 million worth of capital funding and advice to communities aiming to reduce carbon emissions through a combination of low carbon technologies and behavioural change activities (DECC, 2012d). Twenty-two communities that were already active or planning community energy action took part in the project, installing 8,200 low carbon measures and a wide range of engagement activities (DECC, 2012d).

2.5.5.3.2 Feed-in tariffs 2010 - present

The feed-in tariffs scheme (FiT) was introduced in April 2010 to support small-scale, low carbon electricity generation (DECC, 2014h). Under the scheme generators receive a payment, set at the time of registration, for each unit of electricity produced and for each unit exported to the grid. The rate is set by the Department of Energy and Climate Change, is linked to inflation and is guaranteed for the lifetime of the scheme (OFGEM, 2014b). It is assumed that 50% of generation is exported (75% for hydro), for installations with a total installed capacity of 30kW or less (EDF Energy, 2014).

Introduction of the FiT encouraged a higher uptake than expected of low carbon technologies, particularly solar PV (Regen SW, 2011) (Ares et al., 2012). In October 2011, the government announced a consultation about proposed changes to the scheme, including cutting the rate from 43p to 21p for 4kW solar PV systems (DECC, 2011c). The government proposed that the changes were introduced for all installs registered from the 12 December 2011, two weeks before the end of the consultation period. This caused a spike in the rate of installations, with around 7,500 certificates being issued daily compared to 500 per day previously (Cherrington et al., 2013). It also prompted critics to lodge a complaint with the High Court.

On 23 March 2012 the Supreme Court denied the Government leave to lodge an appeal against earlier rulings from the High Court and the Court of Appeal that the proposal was illegal due to the time frame. Regulation put in place after the consultation closed cut the tariff for new installs registered after 3 March 2012 (Ares et al., 2012). These cuts represented a reduction in the rate of return over a longer payback period, lower than those in other European countries (Muhammad-Sukki et al., 2013). The price of installing solar PV has reduced, however the influence of the UK market on the global market for PV models is small, creating uncertainty for UK suppliers (Cherrington et al., 2013). Plans to review the rates every 3 months were announced in May 2012 alongside further cuts in the production rates, increase in export rates and a reduction from 25 years to 20 years in the lifetime of the scheme (DECC, 2012b).

2.5.5.3.3 Local energy assessment fund 2011 - 2012

The local energy assessment fund (LEAF) was a onetime project offering seed-funding for communities planning energy efficiency and renewable energy projects, that ran from December 2011 to March 2012 (Databuild Research & Solutions Ltd, 2014a). Over 600 community groups applied to the fund and £9.2 million was shared between 236 communities, the majority of which had already run at least one project previously (Databuild Research & Solutions Ltd, 2014a). Projects

were all formed of multiple activities with one overall aim to reduce energy consumption and or increase generation (Databuild Research & Solutions Ltd, 2014a). A sample of participants' output since the funding ended indicated that 88% of projects had continued some form of activity (Databuild Research & Solutions Ltd, 2014a).

2.5.5.3.4 Community energy efficiency outreach programme 2012 -2013

The community energy efficiency outreach programme (CEEOP) was an evaluation programme to evaluate the effectiveness of community-scale projects to increase uptake of energy efficiency measures by households and ran between December 2012 and March 2013 (Databuild Research & Solutions Ltd, 2014b). It was a small programme, with just six pilot projects and comparator areas and one online project (Databuild Research & Solutions Ltd, 2014b). Project delivery was carried out by both community groups and local community support organisations (Databuild Research & Solutions Ltd, 2014b). The pilot projects performed better than the comparator areas, suggesting that community-scale projects can work to engage households (Databuild Research & Solutions Ltd, 2014b).

2.5.5.3.5 Community Energy Strategy 2014

In 2011 the Microgeneration Strategy was published containing a chapter on community energy (DECC, 2011e). A call for evidence to develop the community energy strategy was issued in June 2013 and was open for 8 weeks for responses (DECC, 2013b). The Community Energy Strategy was published on 27 January 2014 and it is hoped that it will lead to a significant expansion of the sector (DECC, 2014f). A Community Energy Unit has been formed within DECC and has launched a £15 million Rural Community Energy Fund (RCEF), which will be followed shortly by a £10 million Urban Communities Energy Fund (UCEF) (DECC, 2014c). Information about how the Renewable Heat Incentive (RHI), equivalent to the FIT for heat generation, could be used by communities is being produced (DECC, 2014c).

The strategy acknowledges that community energy can play a part in the energy system, as demonstrated by other countries, however "differences in market structures, energy system governance and wider social and cultural precedents" makes comparison of factors for success difficult (DECC, 2014f). The precise scale of community energy in the UK is unknown, however it is estimated that 5,000 groups have either completed or considered a community energy project since 2008 and there is 49MW of community energy generation in operation (DECC, 2014e). This compares to 85GW of installed capacity of electricity generation in the UK at the end of 2013 (DECC, 2014g).

2.6 Evaluation of the evidence of community energy carbon savings

Research to date has focused on evaluation of project processes (Walker and Stanford, 2014). The following studies all evaluated processes: Databuild Research & Solutions Ltd (2014a) Bird et al. (2013), Seyfang et al. (2013), Hauxwell-Baldwin (2013), Hielscher (2011), Allen et al. (2012), Hoggett (2010), Rogers et al. (2008), Bomberg and McEwen (2012), Databuild Research & Solutions Ltd (2014b), Wiersma and Devine-Wright (2012). The majority of community energy projects are not monitored (DECC, 2014e), however there are some studies which have attempted to evaluate the carbon savings of community energy projects (Databuild Research & Solutions Ltd, 2013).

The LCCC evaluated the impact of community-scale action (i.e. not specifically community energy) across the whole community (DECC, 2012d). One aim was to evaluate the magnitude of carbon emission and energy demand reductions achievable through community-scale activities (DECC, 2012d). A theoretical carbon reduction of 3,062,091kg CO₂/year was calculated from the measures self-reported to have been installed (DECC, 2012d). However it was concluded that there was insufficient evidence to determine the environmental impacts of the challenge, especially the wider impacts (DECC, 2012d). There are plans to analyse the energy consumption of the whole community using national datasets (DECC, 2012d), however the datasets for the time period were only published in March 2014 and the analysis is not yet available.

The Big Green Challenge (BGC) was a competition for community led innovation to deliver measurable carbon reductions run by National Endowment for Science, Technology, and the Arts (NESTA), with a prize fund of £1 million (Brook Lyndhurst, 2010). Ten communities, selected to carry out their plans, reduced carbon emissions by between 10% and 46% (Brook Lyndhurst, 2010). Communities that focused on renewable energy, energy efficiency and behavioural measures achieved higher savings than projects to raise awareness (Brook Lyndhurst, 2010). Neither the report by Brook Lyndhurst (2010) or the policy paper based on the BGC by Houghton Research (2010) make it clear how the carbon emissions were calculated.

British Gas Green Streets community energy challenge gave 14 community groups a share of £2 million capital to stimulate community energy projects which would compete for a prize of £100,000 (Platt et al., 2011). Each group developed a different project, with a range of aims, from reducing energy bills of a community facility to becoming a zero-carbon community. The groups commonly installed condensing boilers, cavity insulation, loft insulation and solar PV. Energy consumption and generation from community buildings and households were measured over three months at the start of the challenge and then compared with baseline data, collected from billing information, to estimate a carbon reduction of 215,461 g CO₂/year (Platt et al., 2011). However the outcomes of the projects depended on the amount of community engagement; the projects have changed local attitudes to energy efficiency measures and microgeneration (Platt et al., 2011). The prize was won by Llangattock Green Valleys, based in Wales (British Gas, 2011).

The Climate Challenge Fund (CCF) was designed to enable communities in Scotland to reduce their carbon footprint. It was set up in 2008 (Brook Lyndhurst and Ecometrica, 2011). Eight projects funded through the CCF had their carbon emission reduction evaluated using the GHG protocol for project accounting by WRI (2005). Both embodied emissions and the impact of behaviour change

were included, although the latter was considered difficult to measure. Two life time estimates of carbon saving were produced for each project: one optimistic and one conservative. When averaged across all projects Brook Lyndhurst and Ecometrica (2011) found that between 46,694 and 15,459 tonnes of CO₂e was saved per project.

The standard to which an evaluation of carbon emission reduction from community energy projects have been carried out is highly variable (Databuild Research & Solutions Ltd, 2013). Only the evaluation of CCF by Brook Lyndhurst and Ecometrica (2011) explicitly states that embodied emissions are included. Although it is assumed that community energy projects have the potential to affect carbon emissions beyond those directly targeted by the project (DECC, 2014f), evaluation usually does not include data collection covering these wider benefits (DECC, 2014e). There is limited empirical evidence therefore to show the magnitude of the impact of community energy projects (Databuild Research & Solutions Ltd and Energy Saving Trust, 2013).

The carbon emission impact of community energy projects, as related to energy supply and demand were identified in section 2.4 as: direct emissions -the project and indirect emissions - income reinvestment and household energy behaviour. These areas are now examined in more depth to identify factors which may affect their potential to reduce carbon emissions for projects that aim to generate renewable energy.

2.6.1 Direct emissions: Project

Community groups did not always select systems which would deliver the highest carbon reduction; selecting instead systems that were perceived to be visible or have good financial benefits, for example solar PV (DECC, 2012d). Platt et al. (2011) suggested that communities were making the “wrong decisions often prefer a ‘flashier’ technology ... above energy efficiency measures”. However amongst community groups there is a perception that seeing technology will encourage uptake (Platt et al., 2011), thus carbon savings from wider installation may outweigh the carbon reduction lost by technology choice, i.e. different technologies may produce different wider benefits (DECC, 2012d).

2.6.2 Indirect emissions: Income reinvestment

Community groups are utilising policy, e.g. FiT and RHI, to create an income stream from their community energy project (DECC, 2012d). This income stream may be used to provide energy advice services, install energy efficiency measures (DECC, 2014f) or into future generation projects (Platt, 2010). Revolving funds created in this way can continue to produce carbon emission savings (Hoggett, 2010). However it is currently largely unknown how the income stream generated through community energy projects is being used and therefore the potential for reducing carbon emissions is not known (DECC, 2014e).

There are examples of community energy projects that have been perceived as unfair due to the distribution of benefits (DECC, 2012d). The concept of fairness can be more complex than initially realised; although the process of distribution may be fair, the distribution of outcomes may be inequitable (Cook and Hegtvedt, 1983). It is important to understand the difference between equal

- “having identical privileges, rights, status etc.” and equity - “the quality of being impartial or reasonable; fairness” (Collins English Dictionary, 2005).

2.6.3 Indirect emissions: Household energy behaviour

Community scale projects may influence energy demand, by increasing awareness of energy issues (Heiskanen et al., 2010, DECC, 2011d). Evidence however is mixed. A community energy project in Ashton Hayes has shown a yearly reduction in energy consumption through an annual survey over five years and monitoring of a local substation (*personal communication, September 23 2012*). Platt et al. (2011) estimated that energy demand reduction due to behaviour change was 2% and that nearly half of surveyed individuals that were aware but not involved with the project would take steps to install energy efficiency or renewable generation. However Rogers et al. (2012) found that attitude changes were limited to those involved with the project and did not extend to the wider community. A report by DECC (2012d) found an increased uptake in some communities of specific measures, they found little evidence of community wide changes in attitudes, behaviour or installation of low carbon generation, beyond a slight increase (4%), compared to nationally, in those that think it normal to reduce their carbon footprint.

“Some of the BGC Finalists managed a moderate scale of reach (several hundred individuals or households) but some of this contact was fairly light touch; others worked in depth with relatively small numbers of households (~50) who achieved marked reductions in emissions.” (Brook Lyndhurst, 2010)

Furthermore changes in attitude do not necessarily lead to changes in behaviour (Hielscher, 2011). An analysis of a small, self-selected sample of households in LCCC areas found no correlation between attitudes towards climate change and the household’s carbon footprint. Only a few households showed any correlation. These all had very large or very small carbon footprints. The carbon footprint was calculated using REAP Petite (see section 2.7.5.1). This raises questions about the assumed link between attitudes and behaviour (Buchanan et al., 2011).

There are two broad types of household behaviour that can affect energy consumption: habitual actions, for example, not boiling a full kettle unnecessarily, and purchasing activities, for example, installing insulation or microgeneration (Barr et al., 2005).

2.6.4 Habitual actions

Catney et al. (2013) suggested that communities are an existing network through which both knowledge and practice can pass between households. The Reducing Energy Consumption through Community Knowledge Networks (RECKKN) project investigated the potential for community knowledge networks to aid in sharing energy knowledge (Dobson, 2013 Overview). They found that through discussion of their energy practices with other participants and monitoring their energy use, participants increased their knowledge. However in order for participants to converse about their energy use the right environment had to be created (Dobson, 2013 Findings). A small qualitative study found that energy information is considered to be the most useful by householders when it is personalised and interactive, for example energy suppliers creating specific plans through bills. The perceived trustworthiness of the information was also important: peers

with experience of measures were perceived to be trustworthy. This would suggest that community energy projects may be able to alter behaviour where traditional actors can't because of the interaction with peers (Simcock et al., 2014). This ties in with findings from a study by Martiskainen (2007), who found that for energy feedback to be effective it must be relevant to the householder.

Preliminary data from The Evaluating Low Carbon Communities (EVALOC) project suggest that even households who did not receive technical or behavioural interventions have reduced their energy use more than would be expected from national trends (Mayne, 2013).

Energy consumption is a consequence of human behaviour and desire for a particular standard of living (Abrahamse et al., 2005). Behaviour change is difficult to measure and attribute to any one thing because total energy use in households is due to a combination of many factors, such as fluctuations in the climate, cost of energy, household size, income and education (Wilhite and Ling, 1995). Studies of the effect of feedback on household energy use have suggested that behaviour changes are short lived as households become used to them (van Dam et al., 2010). Reduced energy consumption does not necessarily reduce carbon emissions; cheaper energy bills may allow households to purchase items with higher carbon emissions than energy, i.e. the rebound effect (Druckman et al., 2011). Rebound is described as either direct or indirect. Direct rebound is where use of a product or service increases due to cheaper running costs from increased energy efficiency. Indirect rebound is where cost savings due to one product or service becoming more energy efficient are used for another product or service (Druckman et al., 2011). The rebound effect may be large enough to cause an increase in energy consumption, known as backfire (Sorrell, 2007).

2.6.4.1 Purchasing actions: energy efficiency

Gupta et al. (2014) found some households reduced their energy demand after participating in a community energy project to install energy efficiency measures. However an evaluation of a scheme to install energy efficiency measures within community boundaries did not find evidence of household behaviour change (CAG Consultants et al., 2011). These differences in findings may be due to behavioural rebound – where energy efficiency measures allow a higher standard of living rather than a reduction in energy consumption (DECC, 2012d). Alternatively it may be due to different levels of community involvement with the project (Walker and Devine-Wright, 2008).

2.6.4.2 Purchasing actions: generation

An analysis of the feed-in tariff database in 2011 found that most areas had no more than four installations, suggesting no community level diffusion of small scale renewable energy generation (Leicester, 2011). However as the feed-in tariff was introduced in April 2010, only a year before the analysis, society would not have had time to adapt to fully utilise the technology at this scale ((Negro and Hekkert, 2010) in (Nolden, 2013)).

Previous studies of householder uptake of low-carbon generation following community scale projects have different finding: Rogers et al. (2012) found increased installations, DECC (2012d) found increased levels of interest, whereas Brook Lyndhurst (2010) found no evidence of increased installations.

2.7 Methods for carbon accounting

Empirical evidence is needed to show the magnitude of carbon saving potential of community energy projects in the UK. Methods for doing this include a simple calculation, life cycle assessment and carbon footprints.

2.7.1 Electricity offset calculation

DECC (2014e) argues that carbon emission reductions from renewable generating projects are easily calculated at the design stage from the installed capacity; i.e. predict how much energy will be produced and then convert this to carbon emissions by assuming that it reduces, or offsets, energy produced by current sources, for example, Energy Share (2012). Tools exist to predict energy output e.g. PVGIS, an online tool to predict the performance of solar PV systems (Šúri et al., 2007). However work by Axapoulos et al. (2014) show that these tools may not be accurate: overestimating global irradiation of the systems, but underestimating the energy generated. This suggests that basing carbon emission reductions on predicted energy generation may be inaccurate.

Many methods assume no carbon is produced by the manufacture and installation of the project. Embodied carbon has generally not been accounted for in studies of community energy projects, for example, Platt et al. (2011) and DECC (2012d). Carbon emissions from the whole lifecycle, i.e. including embodied carbon, can be significant and should be accounted for during evaluation (Varun et al., 2009).

2.7.2 Life Cycle Assessment

The environmental impact of a good or service (product) can be evaluated using life cycle assessment (LCA) methodology; the products life cycle, from material extraction through to disposal is evaluated in terms of its input and output flows (British Standards Institution, 2006a). Application of LCA is flexible, with no single method, however it is an iterative process with four main stages as illustrated in Figure 2-3 (British Standards Institution, 2006a).

There are two distinct types of LCA: attributional and consequential. An attributional LCA looks at the environmental impacts of a product (Earles and Halog, 2011), whereas a consequential LCA looks at the environmental impacts that have occurred due to changes the product has caused (Zamagni et al., 2012). Consequential LCA is newer than attributional LCA and is less well developed (Zamagni et al., 2012).

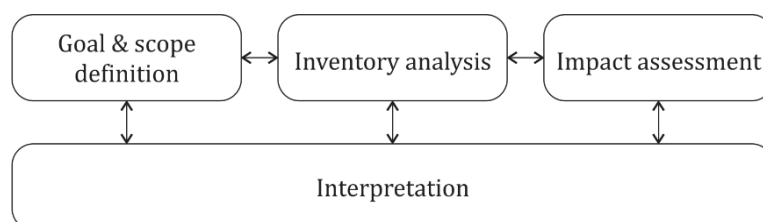


FIGURE 2-3 LCA METHODOLOGY, ADAPTED FROM BRITISH STANDARDS INSTITUTION (2006A)

2.7.2.1 Goal and scope definition

The goal sets out the aims of the LCA and the scope sets out the methodology which will be followed (British Standards Institution, 2006a). During the scoping stage decisions are made about the functional unit and the system boundary (British Standards Institution, 2006a). The functional unit is based on the function or purpose of the product and allows quantification of the input and output flows (British Standards Institution, 2006a). The system boundary identifies which processes in the product life cycle are to be evaluated (British Standards Institution, 2006a).

2.7.2.2 Inventory analysis

The inventory is a quantified list of the input and output flows identified during the goal and scope stage; data for the inventory is collected during the inventory analysis (British Standards Institution, 2006a). The difficulties associated with data collection constrain the scope of the LCA (British Standards Institution, 2006a).

2.7.2.3 Impact assessment & Interpretation

The impact assessment stage maps the inventory data to environmental impact categories (British Standards Institution, 2006a). The interpretation of results should reflect the aims set out in the goal (British Standards Institution, 2006a). Additional analysis is often required to understand the uncertainty and sensitivity of the LCA: uncertainty analysis evaluates how uncertainties in data propagate through the LCA and sensitivity analysis evaluates how changes in data or methodology affect the results (British Standards Institution, 2006b).

2.7.3 Kyoto Protocol

The Kyoto Protocol commits parties to reduce their GHG emissions: the first commitment period ran from 2008 to 2012 and broadly committed to 5% reductions against 1990 levels, the second period runs from 2013 to 2020 with an average of 18% reductions (United Nations, 2014). The Kyoto Protocol requires monitoring of six GHG: Carbon dioxide (CO₂), Methane (CH₄), Nitrous oxide (N₂O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) and Sulphur hexafluoride (SF₆) from specified sectors (United Nations, 1998). The 2012 Doha amendment added Nitrogen trifluoride (NF₃) to this list (United Nations, 2012).

2.7.4 Intergovernmental Panel on Climate Change Global Warming Potential Method

Global warming potentials (GWP) is a metric based on physical sciences (i.e. does not include economic considerations), which describes the relative impact of 1kg of a GHG compared to 1kg of the reference GHG, CO₂ (Forster et al., 2007). GHG have different lifetimes, i.e. CO₂ has a longer life than methane, GWP therefore are time dependant and GWP are available for three time horizons: 20, 100 and 500 years (Levasseur et al., 2010). The list of GHG with GWP is longer than that specified by the Kyoto protocol, see Forster et al. (2007). Only the GWP method was reviewed by Hauschild et al. (2012) as it is based on a widely accepted model and uncertainties are included.

2.7.5 Carbon footprint

Carbon footprints are a truncated form of LCA and therefore do not allow evaluation of the environmental trade-offs of a product (Finkbeiner, 2009). Direct and indirect GHG emissions of a product are reported in terms of carbon dioxide equivalent (Carbon Trust, 2012). There is no definitive methodology for creating carbon footprints, instead a number of protocols exist (Pandey et al., 2011).

2.7.5.1 Existing footprint tools for communities

The Energy Saving Trust (EST) host a community carbon footprint calculator; an online tool for households to record their energy and transport use to be combined with the rest of the community (EST, 2009). It does not appear to have had wide usage; a search of communities near Bath found three groups with no more than 2 members each.

REAP Petite is another online environmental footprint calculator for communities which requires individual households to record expenditure on a range of activities, including energy – results can then be compared against other households in the community (Stockholm Environment Institute, 2014). Unlike many other footprint calculators, it includes life cycle impacts calculated using an input-output methodology which is based on financial markets.

Neither carbon footprint calculator accounts for the wider impacts suggested in the report by DECC (2014f). The EST tool calculator does not consider the indirect emissions from income and it is not clear how accurately it accounts for direct emissions from the project. The REAP Petite tool meanwhile does not allow communities to enter their project activities.

2.7.5.2 PAS 2050: 2011

Publically available specification (PAS) 2050 is a specification for attributional life cycle GHG emissions based on the IPCC GWP 100 years which covers goods and services but not projects (British Standards Institution, 2011).

2.7.5.3 ISO 14064-2: 2012

ISO 14064 is an international standard for GHG accounting and reporting, part 2 of the standard relates to GHG projects (British Standards Institution, 2012a). The standard is flexible, focusing on principles and processes: for example a suitable baseline scenario should be created to evaluate the additionality, i.e. only those GHG reductions that would not otherwise have occurred, however this should be done according to relevant legislation or policy (British Standards Institution, 2012b).

2.7.5.4 GHG Protocol for Project Accounting

The GHG Protocol for project accounting provides a methodology for quantifying and reporting GHG emissions from projects which is flexible to meet policy requirements (WRI, 2005). There is some attempt to monitor life cycle emissions by including what are termed by the protocol secondary effects (WRI, 2005). Electricity supply projects may require dynamic baseline emissions; energy systems will change significantly over time regardless of the project and this should be reflected in the baseline (WRI, 2005).

2.8 Summary

There is a requirement for the energy system in the UK to reduce its carbon emissions over the next 35 years in order to meet the climate change targets set by the British Government. It has been suggested that community energy projects have the potential to reduce carbon emissions not only through the project directly, but also indirectly through use of an income stream created by the project and through behaviour change in the community. In addition it is thought that community energy projects can achieve this without causing tension with the other aspects of sustainable energy: energy security and affordable energy. Therefore in recent years the British Government have become supportive of community energy projects as they create policy in order to meet their energy and climate change targets. In 2014 a community energy strategy was launched and £25 million of funding announced for community energy projects.

Therefore there is a real and current need to answer the question “what is the potential of community energy projects to reduce carbon emissions in the UK?” However this review of the literature has highlighted three specific gaps in the current evidence relating to the carbon saving potential of community energy projects:

1. Current methods of calculating the carbon emissions associated with community energy projects typically do not include life cycle emissions which means that the carbon savings from these projects has potentially been overestimated
2. Evidence of how the income stream generated by the project is being used is currently lacking and consequently the magnitude of carbon emissions associated with its use is also unknown
3. Evidence for behaviour change in the wider community is mixed, therefore more evidence is required in order to calculate the effect of behaviour change on the carbon saving potential of community energy projects

In order to fill these gaps data will be collected from ongoing community energy projects about the project, use of the income stream and energy behaviour in the community. These projects will be based in the UK as it has been identified that the social, political and economic conditions behind community energy projects in other countries are different.

This data will be analysed with a life cycle assessment, using the IPCC impact method to calculate the carbon emissions associated with community energy projects. Life cycle assessment methodology is suited to an evaluation of wider carbon emissions as it encourages inclusion of all important emissions. The IPCC impact method is recognised internationally and has a strong basis in scientific fact.

Carbon accounting is required to justify support of community energy projects. However it can also be used to motivate community groups to keep going (Houghton Research, 2010). Simple standardised models need to be created to help evaluation of community energy projects (Stow et al., 2014), which are not currently available to community groups (DECC, 2014f).

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Although this research focuses on carbon emission reductions only, it should be understood that this is only one of the benefits community energy projects are thought to provide. It would not therefore be suitable to use this research to comment on the success of community energy projects more generally (Hielscher, 2011).

CHAPTER 3 METHODOLOGY

This chapter describes the methods of data collection and analysis that form the backbone of the research process. Where additional analysis was required it is described in detail within the chapter in which the results of the analysis are presented.

The first section describes recruitment of participants to the research study. The second section describes the process of collecting the data used in this research. The third section presents the two main methods of analysing the data: qualitative analysis and life cycle assessment.

3.1 Recruitment

Recruitment of participants took place in the winter of 2011. At this time, there was no database of community energy projects in the UK from which to recruit project participants (Seyfang et al., 2012). Therefore the first stage was to create a database of community renewable energy projects, active at the time, from which to recruit project participants. This database was created using data collected from three websites: energysave (2012), Transition Network (2012) and Carbon Leapfrog (2012).

At the time Energysave was a website where community energy groups in the UK could create a profile and record details of their energy projects, both active and planned. Energysave ran competitions to award funding to community energy groups based on the number of individuals that voted for each project on the website, thus encouraging groups to sign up. The Transition Network website was aimed at groups involved in the transition movement worldwide, this included community energy projects as well as other community projects tackling issues such as waste and food production. Carbon Leapfrog was a charity offering advice to carbon reduction projects that hosted a website that included a few case studies of community energy projects they had been involved with.

A database containing details of 107 community energy groups was created using these three sources. As both the Energysave and Transition Network websites contained details of thousands of community groups and it was not always clear what activities the community groups were proposing or if the profiles were current, a time limit of two days was allocated to extract details from each website. Projects were only included in the database if they appeared to match the following criteria:

1. Community energy project generating renewable energy or actively planning to generate renewable energy
2. Based in England, Scotland or Wales (Northern Ireland was not included as it is part of a separate energy distribution network to the rest of the UK)
3. Community of place
4. Community energy project which includes collective generation

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Due to the time and budgetary constraints of the research it was decided to focus on a particular type of community renewable energy project and look at a large number of examples of this type of project rather than using a small number of examples to investigate a range of project types. Criteria three and four were designed to exclude community renewable energy projects that would conceivably have different wider benefits.

Contact details were not available for all 107 community energy groups. Introductory emails, explaining the research and containing a link to an online survey were sent to the 78 groups on this database that had included an email address. As some groups had included multiple email addresses, 82 individuals were contacted. A copy of the email and online survey are included in appendix A. The survey was created following guidance on good survey design from Oppenheim (1992). The survey was designed to be quick and easy to answer to encourage completed responses. Where possible open questions were avoided, language use was kept simple and phrases were used consistently throughout. The survey was checked for suitability by members of the Sustainable Energy Research Team (SERT) and by the Department of Mechanical Engineering's advisor on ethical issues before being sent.

A paper copy of the survey can be found in the appendices, however it should be noted that the original format of the survey was online and contained filtering questions. Therefore not all groups were asked all questions. For example it was felt inappropriate to ask questions about monitoring of energy generation if the group had indicated that they were not undertaking energy generation.

21 groups (22 individuals) completed the survey. This included one group that did not appear on the database. This group had been sent the survey by one of the groups included on the database that had previously worked with this group. Four groups responded uniquely by email indicating they were unsuitable participants for the research as they were either not currently active or felt that the research was not aimed at any of their activities. Five emails could not be delivered as the email address was now invalid. The responses to this survey are presented in Chapter 4.

The final question on the survey asked the participants to indicate if the community group were willing to take part in further research. The further research was described as an interview and monitoring of energy generation and use. At this stage 18 groups indicated that they wished to participate further in the research.

Two groups were excluded as they did not meet criteria one as they no longer planned to generate renewable energy. One group did not meet criteria three and four groups did not meet criteria four. However the interviews carried out suggest that the boundaries between community energy projects including generation on community buildings and on individual households are often blurred.

The 12 groups that met all criteria were contacted in order to set up a time for a face-to-face interview. One group did not respond to further attempts to contact them. Two additional groups, that met the criteria, were interviewed after being introduced through contacts made during the research process.

Ten of the groups were based in England and three in Wales. None of the groups based in Scotland indicated that they were willing to participate in the interview stage of the research. DECC (2014e) found that Scotland had a higher number of community groups than would be expected from its population. Community energy in Scotland has had longer term investment in the sector, such as the Climate Challenge Fund in 2008 (see Chapter 2). The conclusions drawn from this research may therefore not be applicable in Scotland.

3.2 Data collection

The primary data on which this research is based was collected through face-to-face semi-structured interviews (Oppenheim, 1992, Banister et al., 2002, Ritchie and Lewis, 2003). For each of the 13 community energy groups that participated in the research one interview was carried out with at least one representative from the group.

Interviews were used in order to help establish a good working relationship with the groups and to collect qualitative data about the community groups. Although the research question could be answered purely through quantitative research methods, there was a desire to explore the how and why aspects of the question, as well as just the what. The data from the interviews provides an understanding of the factors limiting the carbon saving potential of community energy and which of these factors can be changed and which cannot.

Data collected in the interviews are used throughout the research and consequently the methodology of collection is described in the following sub-sections. Where necessary data was collected from the community group's websites to supplement interview data. A list of websites used have been included in the following sub-sections and their use indicated throughout the work. Where other sources of data are used they are described alongside the method used to analyse them.

3.2.1 Interviews

Interviews took place at a location and a time selected by the interviewee to minimise disruption and create an environment in which they felt comfortable. The interviews were carried out between November 2012 and April 2013.

Seven interviews were conducted where one representative of the community group was present. Four had two representatives present at all times and one had had two representatives, one after the other. One was conducted with one representative whilst their partner was present. One interview was conducted by two interviewers. The representatives for the groups were generally the individuals that had been the initial point of contact. These individuals frequently indicated they had been given approval to participate from the rest of the community group. The roles these interviewees played within the community group are indicated in Table 3-1. All interviewees, with the exception of one, formed part of the core group. However they had a variety of roles within this from chair through to secretary. The majority of interviewees were directors however they had a range of backgrounds and interests, from technical through to social aspects of the project.

Twelve of the interviews were recorded using a small portable mp3 recorder which was positioned on a table in front of the interviewees, on a small stand. Prior to the recorder being switched on, interviewees were asked for verbal consent for the interviews to be recorded. One interview was not recorded due to unavailability of a recorder. For this interview notes were made during the interview by the interviewer. Written consent to use the data collected and name the community group was also gained.

TABLE 3-1 ROLES OF INTERVIEWEES WITHIN THE COMMUNITY ENERGY GROUPS

Role	Count
Centre manager	2
Chair	4
Director	7
Member	2
Secretary	1
Treasurer	2
Other	1
Total	19

A list of questions was prepared in advance of the interview in order to collect a wide range of data. These questions were a mix of both closed and open questions. The topics were designed to gather specific data about the projects, such as technical details (i.e. installed capacity) as well as to encourage discussion about the development of the community group and the community energy project and the responses and changes within the community. This list is included in the appendix. The questions were checked for suitability by members of SERT prior to the first interview. The same list of questions was used for all interviews with the exception of the interview carried out by two interviewers, where a supplementary list of questions were also asked. The questions are included in the appendices.

Interviewees were not sent the list in advance, but were given a general idea of the topics the questions would cover beforehand via email. Topics were not constrained to those on the list; interviewees were given time to expand on ideas that they introduced. However care was taken to move the conversation back to the prepared questions once the interviewees had exhausted a topic of conversation. The interviews rarely followed the format of the list. Interviewees frequently alluded to topics in different orders or answered questions without being explicitly asked and care was taken to make the interview feel as natural as possible.

3.2.2 Transcription

Recorded interviews lasted on average 67 minutes. The shortest interview was 46 minutes, with the longest taking 114 minutes. Transcription was carried out by the interviewer using VLC media player to playback the recordings, and Microsoft Word to compile the transcripts. Two recordings contained a high amount of noise making transcription difficult (both had taken place in a busy café setting). These recordings were first processed using Audacity 2.0.3 software to reduce the level of noise. Only the spoken word was transcribed, body language, pauses and intonation were not recorded. Transcripts were sent to the interviewees asking for confirmation of their accuracy which elicited some minor alterations relating to proper nouns.

3.2.3 Websites

Where specific data about a project was not clear from the interviews, i.e. the installed capacity or if it was known that a planned project discussed during the interview had significantly changed then data was collected from the group's website and other associated websites. Table 3-2 gives a list of websites used for this research.

TABLE 3-2 LIST OF PARTICIPATING COMMUNITY GROUPS WEBSITES AND WEBSITES OF ASSOCIATED ORGANISATIONS

Group	Websites
Crucorney Energy Group	http://crucorneyenergygroup.tumblr.com/
Easton Community Centre	http://www.eastoncommunitycentre.org.uk/ http://www.bristolenergy.coop/
Green Transition Eynsham Area	http://greenteaoxon.net/ http://www.lowcarbonhub.org/
Hebden Bridge Town Hall	http://www.hebdenbridgetownhall.org.uk/
Hexham River Hydro	https://hexhamriverhydro.wordpress.com/
Llangattock Green Valleys	http://www.llangattockgreenvalleys.org/ http://www.llangattockgreenvalleys.co.uk/
Low Carbon Gordano	http://lowcarbongordano.co.uk/ http://lcgshareoffer.org/
OVESCO	http://www.ovesco-ips.co.uk/
Pennine Community Power	https://powerinthecommunity.wordpress.com/
Sheffield Renewables	http://www.sheffieldrenewables.org.uk/
Snitterfield Actioning Climate Change	http://www.snitterfieldacc.org/
Talybont on Usk Energy	http://talybontenergy.co.uk/
Whalley Community Hydro	http://www.whalleyhydro.co.uk/

3.3 Data analysis

This section presents the various methodologies used in this research, starting with the methodology of the qualitative analysis, the results of which are reported in Chapter 5. The second sub-section presents the methodology for the life cycle assessments (LCAs). Figure 3-1 shows how these methods are used in the thesis and the sources of data for each chapter. The qualitative analysis in Chapter 5 is used to inform the boundaries of the LCA used in Chapters 6, 7 and 9.

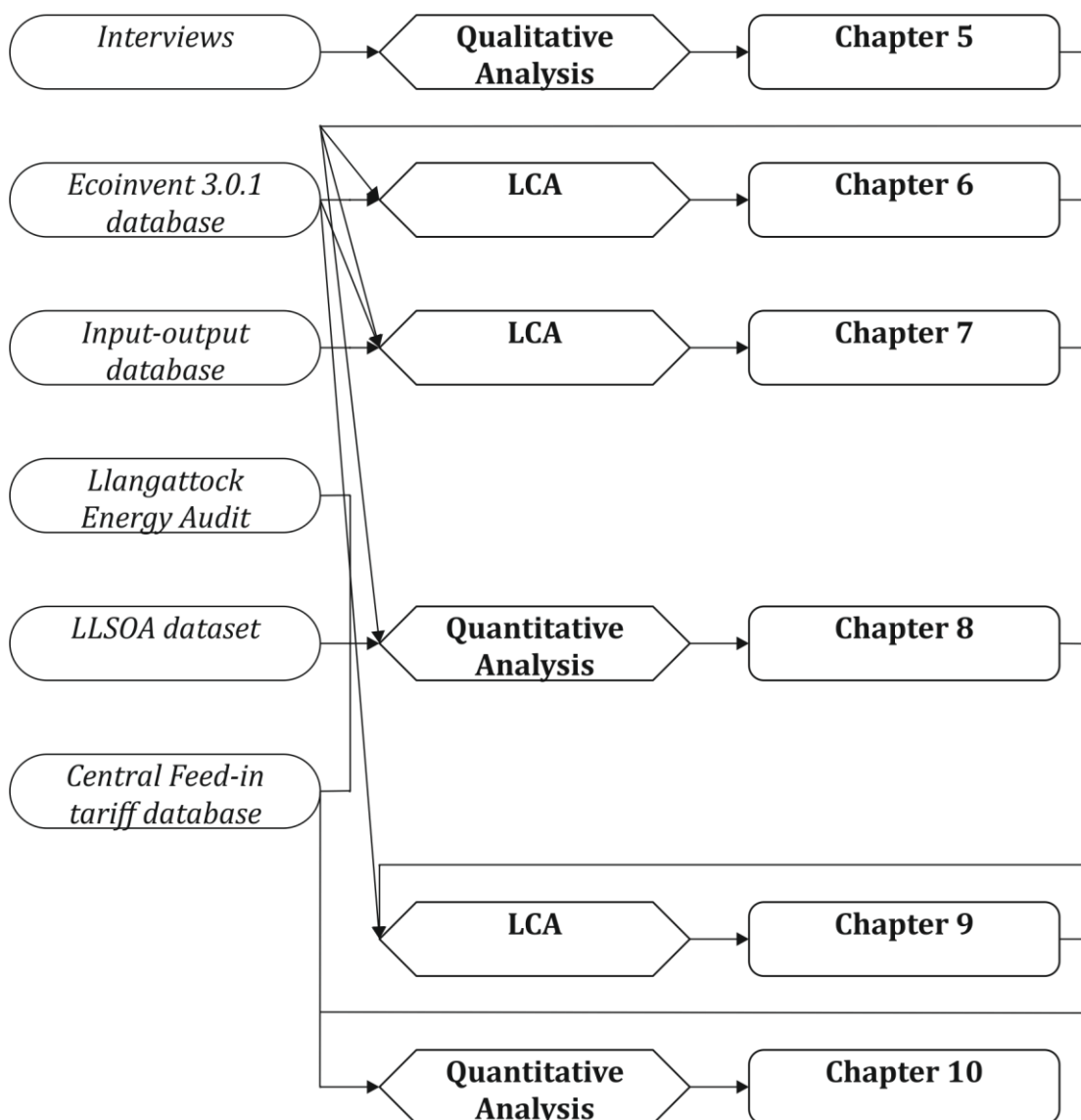


FIGURE 3-1 FLOWCHART SHOWING CONNECTION BETWEEN QUALITATIVE, QUANTITATIVE AND LCA ANALYSIS

3.3.1 Qualitative analysis

Qualitative analysis of the interviews was undertaken to fulfil objective 2 – examine why certain courses of action are taken during the delivery of a community energy project. The analysis undertaken was thematic in nature. The transcripts were first studied and then indexed (or coded). This was done using reviewing tools in Microsoft Office Word 2010. Due to the solitary nature of

the research (i.e. it was not undertaken by a team of researchers), it was not possible to reduce the potential for researcher interpretation bias by using multiple researchers to index the same transcripts. Instead after the transcripts has been indexed initially, a period of reflection was allowed, to identify the potential biases that could have affected the indexing process. The transcripts were then indexed again with these bias in mind.

The data were then sorted into the index categories and presented in a matrix format in Microsoft Office Excel 2010. Care was taken to include both positive and negative opinions from interviews in the categories. For example a category created from the transcripts covered the legal structure of the community groups, in this category reasons why a legal structure had been picked were included as well as reasons why a legal structure had not been picked. At this stage the data retained key phrases from the interviewees and an attempt was made to minimise the amount of interpretation of the data.

The matrices were then reviewed and interpreted by the researcher, again allowing for a period of reflection of potential biases. The categories were then arranged into themes which are discussed in Chapter 5. The majority of these themes were generated directly from interpretation of the transcripts. However most themes contained in Section 5.2, which explores the factors that affected the development and implementation of the project, were deliberately drawn out of the transcripts as they were required for the boundary conditions of the LCA.

The use of quotes in the analysis presented in Chapter 5 was kept minimal to ensure that all views were discussed with equal merit in the space available. Quotes were included where they represented a view, or series of views that it would not have been possible to accurately represent without the precise use of language included in the quote.

The researcher's interpretation of some of the transcripts was checked during further email correspondence (and in one instance follow up meeting) with the interviewee. The research was also presented at an event to which the community groups had been invited.

3.3.2 Researcher perspective and bias

The researcher's view of the world closely matches that of relativism as described by Ritchie and Lewis (2003) that:

- "reality is only knowable through socially constructed meanings"
- "there is no single shared social reality, only a series of alternative social constructions"

Her view of research subscribes to the interpretivism stance described by Ritchie and Lewis (2003) that:

- "The researcher and the social world impact on each other"
- "Facts and values are not distinct and findings are inevitably influenced by the researcher's perspective and values, thus making it impossible to conduct objective, value free research, although the researcher can declare and be transparent about his or her assumptions"

- “The methods of the natural sciences are not appropriate because the social world is not governed by law-like regularities but is mediated through meaning and human agency; consequently the social researcher is concerned to explore and understand the social world using both the participants’ and the researcher’s understanding”

The researcher grew up in an environment that both valued and participated in community action, for example the household in which she grew up belonged to a food cooperative. However as an engineer she believes it is also important to investigate claims made of the benefits of community action rather than accepting them at face value because they sound attractive.

The researcher had no prior knowledge of the majority of villages and towns in which the community energy groups were based. However two of the community groups were based in locations close to the town that the researcher had grown up in. A conscious effort was made to not include personal knowledge of these communities in the analysis.

The majority of interviewees had no prior link to the researcher. However one was known personally by the researcher and another known personally by the supervisory team. It was considered that this could have affected the openness of the interviewees, however the extent of information disclosed appeared to be very comparable to that of other interviews.

The majority of interviewees did not know the researcher, were aware they were being recorded and were placed in the formal setting of an interview taking part in research. This undoubtedly will have had some effect on their responses. However interviewees were remarkably candid about certain events and several used language that indicated the interviewer was treated as a trusted confidant, despite the nature of the meeting.

Although the transcription and subsequent analysis focused predominantly on the content of the interviews and the tone of the interviewee was not recorded, the data were interpreted with reference to the interviewee’s personality as perceived by the interviewer. For example one of the interviewee’s was felt to be sarcastic in many of their responses and would therefore have been misinterpreted if this was not considered during the analysis.

The data were interpreted as subjective perceptions rather than objective facts. Whilst many interviewees referred to notes when asked closed questions, the open questions reflect the viewpoint of the individual interviewed rather than the community group they represented. This was apparent in interviews where two members were interviewed – their viewpoints were not always identical. Therefore for the qualitative analysis the data was anonymised and presented as a reflection of the sector rather than the individual groups that participated.

Interviews were carried out only with one type of stakeholder: core members of community energy projects. Therefore analysis relating to other bodies, i.e. the Environment Agency, is a one-sided analysis presenting the subjective perceptions of the community groups.

3.3.3 Life cycle assessment (LCA)

The results of life cycle assessments are presented in four of the chapters, six through to nine. Chapters 6 to 8 each contain a different segment of the LCA. Chapter 9 contains the combination of the results of the three previous chapters. As the same method is applied across all chapters the overall methodology is presented here. The specific details of each stage of the LCA can be found within the chapter they are presented in. The methodology is presented here following the first three stages of LCA methodology set out in British Standards Institution (2006a): goal and scope, inventory analysis and impact assessment. These stages are discussed within the literature review in Chapter 2.

3.3.3.1 Goal and scope

The aim of the LCAs in this work is to assess the net carbon emissions attributable to the individual case studies in this research including those of the project itself and two of the potential indirect benefits: income reinvestment and energy behaviour change.

The research uses consequential LCA methodology. A consequential LCA assesses the environmental impacts that occur due to the changes the product has caused (Zamagni et al., 2012) rather than an attributional LCA which only looks at the impacts of a product (Earles and Halog, 2011). Therefore consequential LCA is a very appropriate method for a research question that investigates the wider benefits of a product, i.e. the changes the product has caused. The results of consequential LCAs however, are closely linked to assumptions made about the changes caused, for example the carbon intensity of grid electricity offset. Therefore there is a need to make such assumptions apparent. All general assumptions are laid out in this chapter.

In order to fulfil objective 7, which requires a comparison of the carbon footprints created using LCA methodology, the functional unit and the system boundary of the footprints need to be consistent. The functional unit should be based on the function of the system and allow both input and output flows to be quantified. The functional unit used for all community energy projects modelled in this work is the installed capacity of the project.

The system boundary followed is illustrated in Figure 3-2. This system boundary applies for 25 years of community energy project beginning from the start of the idea for the particular community energy project modelled. This time period was selected as it ties in with the widely used lifetime of renewable energy technologies and the length of time that the feed-in tariff was guaranteed to generators prior to August 2012. It should be noted that the results of this LCA should not be used to directly compare to any other scale of system unless the same methodology is used.

The life cycle modelled in this work is cradle to use, i.e. disposal is not included in the overall system boundary. There are two reasons that disposal has not been included within the system boundary. Firstly nearly all technologies modelled in the LCA, with the exception of invertors for PV systems and boilers and windows modelled within the income chapter, have a lifetime of 25 years or more and consequently would not be disposed of within the timeframe measured. Secondly little is known about how the technologies will be disposed of. This second point is discussed further in the qualitative analysis presented in Chapter 5.

Although the analysis is undertaken on specific case studies, the research is designed to be generally applicable to all community energy projects in the UK that meet the inclusion criteria set out in the first section of this chapter. Therefore generalised inventory data for the UK were considered to be of more relevance than highly specific data from each community group or individual manufacturers.

The results of the project segment of the LCA are presented in Chapter 6. This segment models the impact of the project installed by the community group. Chapter 7 presents results of the income reinvestment segment of the LCA. This segment models the impact of the community group using the income stream, for example paying shareholders or installing energy efficiency measures in the community. The results of the behaviour change segment are presented in Chapter 8. This segment models the impact of two types of behaviour change that could have occurred in households in the community (energy use change and installation of renewable energy) due to increased knowledge or acceptance because of the community energy project.

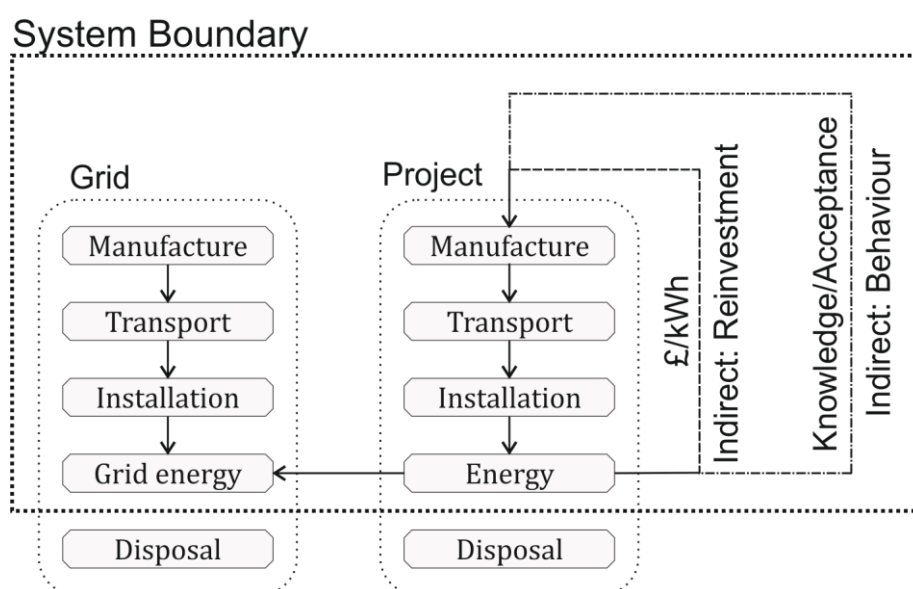


FIGURE 3-2 SYSTEM BOUNDARY

3.3.3.2 Inventory analysis

The inventory analysis produces a list of all the material flows in and out of the system. For this LCA generalised data of material flows, i.e. mass of silicon required for 1kW of installed capacity, were calculated using the installed capacity of each community energy project. The majority of material flow data was taken from the Ecoinvent 3.01 allocation database (Ecoinvent Centre, 2014). This database is considered to be a good repository of data as assumptions are transparent, relevant for Europe and up to date.

PV systems have been based on polycrystalline (multi-Si) panels because this is the style of panel that had been installed by those groups that knew what had been installed.

Material flow data were not available from this database for reverse Archimedean screws. There is a lack of literature and data about the design of such generators because they have only recently

started to be installed in Europe (Lyons and Lubitz, 2013). Therefore material flow data for this technology are based on a scaled 50kW screw from McNiven and McManus (2014). The scaling was done making assumptions about the geometry of the screw from available data about each site such as change in height of the water (head) and flow rate. The length was calculated using the head and an assumption of a 22° angle (Lyons and Lubitz, 2013) i.e. $length = head \times \sin \frac{22 \times \pi}{180}$. The diameter was calculated based on the flow rate that would be required for the estimated power output i.e. $Flow\ rate = \frac{Power}{Head \times \rho \times g \times 0.77}$ (Lyons and Lubitz, 2013).

The actual generation of most systems was unknown. This was for a variety of reasons:

1. The project was not yet installed
2. The community group did not know the generation because they did not have easy access to the installation as they did not own or manage the building it was installed on
3. The community group did not have an automatic system of recording energy readings and sending readings manually would take too much time for volunteers

There are a variety of tools freely available to calculate the average generation of an installation in a particular location, for example PVGIS (Šúri et al., 2007), however, Axapoulos et al. (2014) found that such software tended to significantly underestimate generation when compared to actual performance. Therefore in order to maintain basic and transparent assumptions where possible a decision was made to use the mean annual UK generation for PV systems given in BRE (2012). Therefore for PV systems an annual generation of 830kWh per kW of installed capacity was assumed for the first year of operation. A degradation of 1% of generation per annum was then applied for subsequent years. This was based on the maximum degradation covered by a number of major polycrystalline panel manufacturer's warranties that was averaged and then rounded to the nearest whole number. Predicted generation from wind and hydro systems is closely linked to conditions at a particular site. Therefore predicted generation for projects involving these systems is based on the generation predicted by the community groups planning these projects. Hydro systems in particular are typically designed by companies who have experience of installing such systems and consequently there is a degree of certainty using these figures.

Calculation of material flows for the indirect emissions (income and energy behaviour) was done using the same data. However to calculate the material flows for the income, the amount of income generated was first calculated from the predicted project generation. The income was then divided between uses based on data from the interviews and then translated into material flows where possible. More detail is given in Chapter 7. Chapter 8 describes the method used to calculate energy behaviour.

3.3.3.3 Impact assessment

The life cycle inventory was built in Simapro 8 using the Ecoinvent 3.01 allocation database (Ecoinvent Centre, 2014). The inventory was analysed using IPCC 2007 (100 year time frame) which transforms greenhouse gas emissions into kg of CO2 equivalent.

There is not a fixed value of CO₂eq per kWh of grid electricity; a wide range of values have been used to calculate the carbon impact of electricity (Market Transformation Programme, 2009). This is due to the way in which the national grid operates with a number of different types of power plants, e.g. coal fired, gas fired, nuclear and wind etc. Each individual plant provides electricity with a different carbon impact. There is no way of knowing where any unit of electricity originates or therefore its carbon impact. Additionally the proportion of power from each plant varies constantly. Hitchin and Pout (2002) argued that small changes in demand would have the effect of reducing power output from marginal power plants that tend to have a higher carbon impact per kWh than base load power plants. Base load power plants provide the minimum load required by the grid at all times (i.e. a constant load), these types of plant are usually nuclear, which has a low carbon impact. Marginal power plants or peaking power plants change their power output in order to meet demand on the grid. It has also been argued that the fuel mix supplied to the residential sector differs significantly to the system wide mix as much of the nuclear generated electricity is supplied to industry in bi-lateral contracts (Boardman and Palmer, 2007). However the main focus of this research is not to determine the carbon impact of a kWh of electricity, but of a community energy project. Therefore this research uses carbon intensities based on the annual system-average (i.e. the carbon impact is determined by multiplying the carbon emissions from each type of power plant by the amount of power it provided to the grid averaged over one year) to reflect current standards of reporting in the UK, but acknowledges that the carbon impact of electricity is still under discussion (Burgess et al., 2011).

Within the time frame modelled in the system boundary the carbon impact of grid electricity is likely to change substantially. For example many coal plants are due to close and those remaining will be limited in their hours of operation due to the Industrial Emissions Directive (Energy and Climate Change Committee, 2012b). Therefore the carbon impact of grid electricity over this time period was based on the low voltage thousand flower pathway results by Hammond and O'Grady (2014)¹ as part of the Transition Pathways projects. The thousand flower pathway is a scenario where it is imagined that households, local authorities and communities play a larger part in the energy system (Transition Pathways, 2012). The pathway does not represent an absolute truth, it is a model of the potential outcome if a particular set of actions are taken. This model was selected to be used in this research because:

1. It is not appropriate to use current values of grid carbon intensity as it is recognised that they will change over the time scale modelled
2. Transition pathways results are based on life cycle assessment methodology and is based on the UK
3. The thousand flower pathway reflects the subject matter of this research, i.e. a grid with more community involvement
4. The results used in this work included transmission and distribution losses

¹ Updated figures provided by O'Grady 31/07/2014

CHAPTER 4 CASE STUDIES

This chapter builds the profile of the community groups that participated in the research and places them in the context of the sector. This shows how objective 1, to recruit and collect data from community energy groups that have installed or planning to install renewable energy generation as part of a community energy project, was met and the validity of applying this research to the sector.

This chapter contains three sections. The first section is an analysis of responses to the recruitment survey. The characteristics of the 13 community groups that were interviewed for this research (the research sample) are compared to the profile of the community energy sector reported by DECC (2014e) in the second section. The final section contains a short introductory narrative of each community group that make up the sample that forms a basis for interpretation of the results presented in Chapter's 5 to 9.

4.1 Recruitment survey results

The results of the survey sent out as part of the recruitment process are presented in the following sub sections. Each section relates to a question or series of questions on the survey. A paper copy of the survey can be found in the appendices. A total of 21 community groups responded to the survey which was sent to 78 groups. One respondent had been sent the survey by another group rather than directly and consequently the completion rate was approximately 27%. The results are presented here per community group. The two responses received from two individuals about the same community group were in agreement and therefore were combined before analysis.

4.1.1 Structure

The breakdown of community group structure, identified by survey respondents is illustrated in Figure 4-1. The top three categories, shown in black, are examples of incorporated structures, i.e. they are recognised as a separate entity by the law and members are not liable for debt. The next four categories, shown in grey, are unincorporated structures. The individuals within unincorporated structures are liable for any debts the group accrues (GOV.UK, 2014a). The final category, shown in hatching, represents groups that have achieved charitable status in addition to their main structure. Both incorporated and unincorporated organisations can become charities (GOV.UK, 2014c).

There is an even split between groups that are incorporated and those that are not with 10 groups in each category. One group identified themselves only as a charity. The structure of the group does not appear to be linked to the stage of community energy project, i.e. both incorporated and unincorporated groups had both installed or were still planning energy generation.

THE CARBON SAVING POTENTIAL OF COMMUNITY RENEWABLE ENERGY IN THE UK

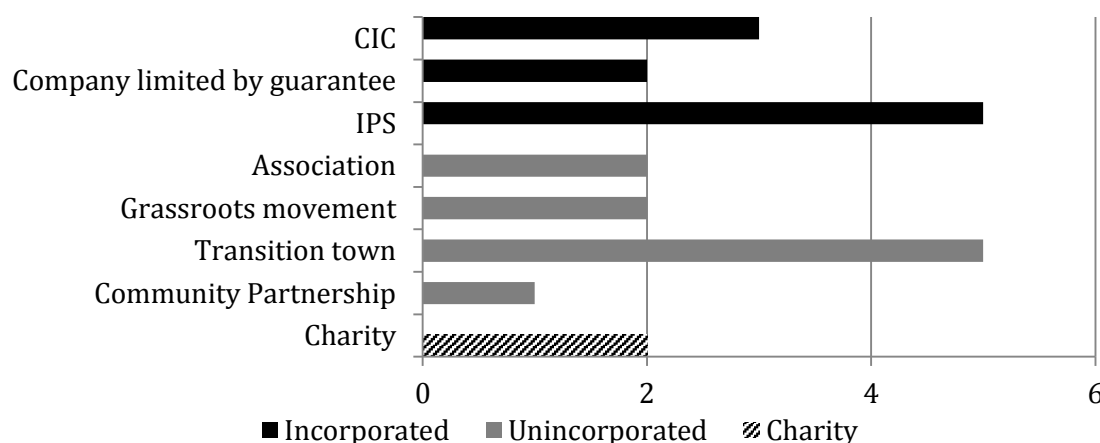


FIGURE 4-1 STRUCTURES OF COMMUNITY ENERGY GROUPS

The most popular incorporated structure was that of an Industrial and Provident Society (IPS), which were first introduced in 1965 (HMG, 1965). There were two types of IPS: for the benefit of the community and co-operative (i.e. for the benefit of the members)². IPS can issue withdrawable share capital often referred to as community shares. This type of share may be sold back to the IPS for its face value (i.e. share value doesn't rise or fall) and interest can be paid to shareholders. However the maximum limit an individual can hold is capped, prior to 6th April 2014 this cap was £20,000, post this date it is £100,000 (Financial Conduct Authority, 2014). This next most popular type of incorporated structure are community interest companies (CIC). CICs were introduced in 2005 under the Companies: Audit, Investigations and Community Enterprise Act (HMG, 2004) in order to create a company type that could be ensured to be working for the benefit of the community. CICs can issue shares that pay dividends however this is capped by the Secretary of State. CICs cannot be charities (Office of the Regulator of Community Interest Companies, 2013). There were two groups that identified themselves as companies limited by guarantee. This type of company doesn't issue shares.

Of the unincorporated groups the highest number identified themselves as transition towns. Transition towns are based on the idea that local action e.g. community gardens can enable resilient communities with a small impact on the environment (Transition Network, 2015). Two groups identified as a grassroots movement – organisations that form in order to tackle a local issue that has arisen. Two groups did not identify what type of unincorporated association they were, hence have been listed as associations. One group identified as a community partnership: a series of organisations working on the same project.

² The Co-operative and Community Benefit Societies Act 2014 replaced the title IPS with either a community benefit society or a co-operative society which are classified as "registered societies" (Financial Conduct Authority, 2014). However as this came into force on 1st August 2014, after the data had been collected, IPS is used throughout. It is not known which of the two forms these groups have taken as interviewees frequently referred to their groups as both a co-operative and for the benefit of the community.

The structure selected has implications for the group. On the 1st December 2012 (i.e. after this data was collected), the Government implemented a series of benefits available only to schools and community groups (FIT community team, 2013). It was determined that only CICs and IPSs (both co-operative societies and community benefit society forms) with less than 50 employees would be counted as community organisations – charities do not qualify for these benefits. According to this survey therefore only 36% of respondents would be eligible to receive benefits designed for community groups.

4.1.2 Activities

Respondents were asked to select which activities they were currently involved with from a list of nine options. Respondents were able to select as many as were applicable and were also given space to add other activities. The nine options were based on the sorts of activities that had been observed to be popular during creation of the community energy database which was used for recruitment. In addition to these nine activities, respondents identified a further three activities: challenging energy perception, transport and recycling. Apart from recycling these activities were identified by more than one respondent.

Figure 4-2 shows the number of groups undertaking each activity. The series of columns labelled “All” is the aggregated response from all respondents. The series labelled “Generate energy” represents the aggregated response from the 17 respondents that had indicated that their group were involved with energy generation. This survey was only sent to community groups that were thought to be generating energy. There are two reasons why only 81% of respondents were involved with generating energy. Firstly the question was not completed accurately by all respondents: one respondent indicated the group was not generating energy on the survey but sent an email explaining that they were. Secondly information on the websites used for creation of the recruitment database was out of date. This indicates the importance of communicating directly with community groups.

Respondents reported 81 counts of different activity they were currently undertaking with a mean count of 3.9 activities per group, ranging from zero to 10 activities. The most common activity was energy generation, however this was the target activity of the sample. The next two most common activities were offering advice about and installing energy efficiency measures with 14 and 13 groups in total respectively indicating they carried out this activity. Only three groups that offered advice did not also install energy efficiency measures and only two groups installed measures without providing advice.

Monitoring of energy use was undertaken by nine groups, all of which were also installing energy efficiency measures. Thermal imaging of heat loss was carried out by seven groups, all of which were offering advice on energy efficiency measures, three groups were also monitoring energy use. This could suggest that monitoring energy use is seen as an evaluation tool, whereas thermal imaging is being used as an educational tool by community energy groups, although more research is required to confirm this. Both supply switching and challenging energy perception were carried out by a small number of groups, four and three respectively, all of these groups were also generating energy.

THE CARBON SAVING POTENTIAL OF COMMUNITY RENEWABLE ENERGY IN THE UK

The remaining activities all relate to non-energy activities. Providing a community garden, orchard or woodland was the most common of these activities. Providing community space, alternative transport, i.e. car clubs, providing recycling and swap shops (everyone brings an item they no longer want and swaps it with someone else) were carried out by only a few groups each.

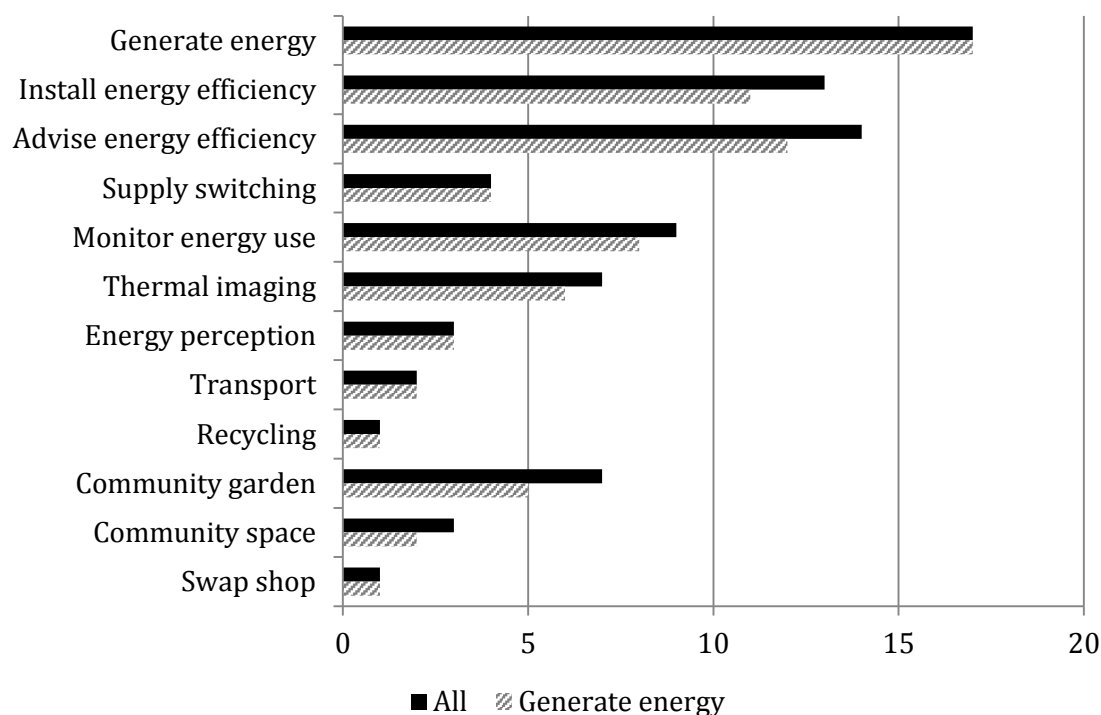


FIGURE 4-2 ACTIVITIES UNDERTAKEN BY COMMUNITY ENERGY GROUPS

4.1.3 Energy generation

The type of energy generation installed or planned is shown in Figure 4-3. AD stands for anaerobic digestion, a process which turns organic waste products into energy. It was not always clear from the responses what technology the group had chosen, particularly for projects at the planning stage. This is represented by the “unknown” category. The total number of projects represented in the graph is more than the number of groups that indicated they were involved with energy generation. This is because some responses indicated that a number of projects had been undertaken. The total number of installations of a technology could be higher than indicated by this graph i.e. “solar PV on domestic households” was counted as one project.

In total 21 projects had been completed to the point of generating energy. A further 18 projects were planned. 10 respondents indicated that their group were monitoring the energy generated by at least one of their projects.

Solar photovoltaic (PV) systems had been installed by just over half of the groups that were generating energy. Some of these groups listed several different installation sites. However only one group planned to install this technology. This suggests there may be a decline in the number of new PV systems. The next most common technology was hydro; three groups were generating

energy using a hydro turbine. More groups were planning to install hydro than had already installed it. This could suggest that hydro schemes are gaining popularity. The same could be said of wind; more groups were planning wind projects than had already been installed. One group had installed solar thermal technology and one group planned to do so. One group was undertaking a feasibility study of anaerobic digestion (AD). The technology of seven projects at the planning stage was unknown. This is likely to be because this information was not asked for rather than indicating that the projects were at an early stage of planning.

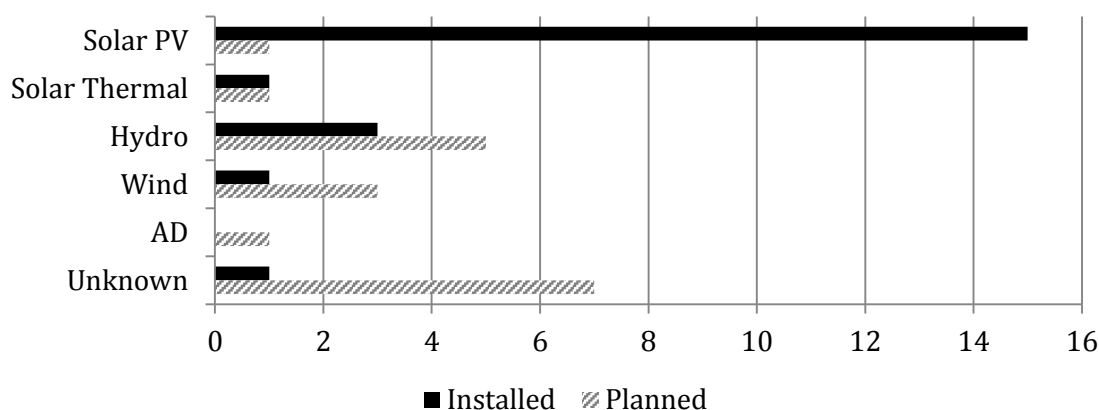


FIGURE 4-3 ENERGY GENERATION INSTALLED OR PLANNED BY COMMUNITY GROUPS BY TECHNOLOGY

The description given of each installed project indicated whether the project was installed on a community building or land or on households. A breakdown of where projects had been installed is shown in Figure 4-4 by technology. Hydro projects are not included on this graph because their location was not described. The wind and solar thermal projects were installed either by or on households. More solar PV projects were installed on community buildings than on households. However the survey asked about projects rather than individual installations, therefore the actual number of separate installations may be higher on households than on community buildings. In addition the sample would be biased towards community buildings due to recruitment criteria four.

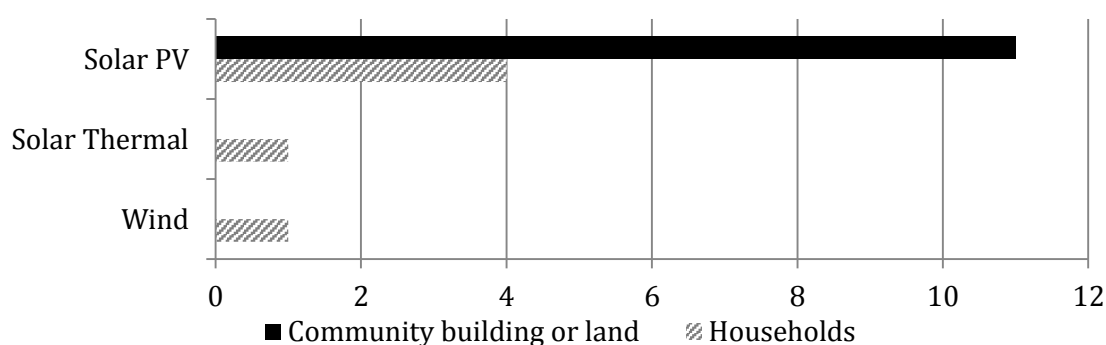


FIGURE 4-4 ENERGY GENERATION INSTALLED BY COMMUNITY GROUPS BY LOCATION

4.2 Comparison of research sample to UK community energy sector

When the community groups were recruited to participate in this research there was no database of community energy projects in the UK (Seyfang et al., 2012). Therefore it was not known how completely the research sample represented the sector. Subsequently however a report by DECC (2014e) was released that attempted to identify the scale of community energy activity in the UK. Due to the nature of the sector it is not certain that the analysis carried out for the report includes all community energy activity (DECC, 2014e), however a larger number of community groups participated than in this research.

A database of 4,706 community groups was compiled from a number of sources. Projects focusing on renewable energy accounted for 47% of the groups from the database, for which project type was known. These groups have installed 49MW of community energy capacity. A survey designed to capture data about the profiles of community groups was completed at least partially by 177 communities and energy professionals (DECC, 2014e).

The profiles of the research sample, which included 13 community groups, is compared to the results reported in DECC (2014e). As the two profiles are based on different numbers of community groups, the data are represented as percentages to allow comparison. The number of community groups or projects represented in each graph for the two samples is recorded in the legend of each graph, i.e. (n=x).

4.2.1 Community group

The sector has experienced a recent growth in size; the CE in UK study found 42% of community groups formed in 2010 or afterwards. Figure 4-5 shows that the sample that participated in this research closely match this, with 46% of groups forming in 2010 or afterwards.

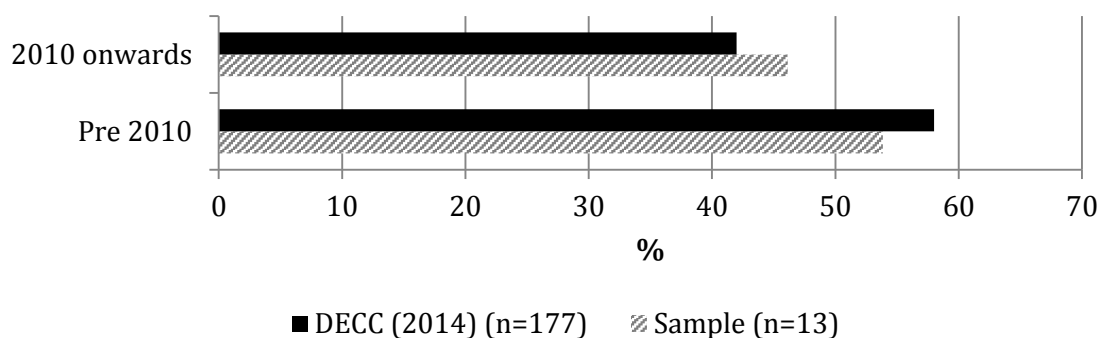


FIGURE 4-5 COMPARISON OF YEAR OF GROUP FORMATION

A comparison of the structure of the community groups is shown in Figure 4-6. Two of the groups that are companies limited by guarantee are also charities. DECC (2014e) found that community groups focusing exclusively on renewable energy were less likely to be charities than groups focusing on other activities. These two groups were not solely focused on renewable energy.

Unconstituted groups, IPSs and companies limited by guarantee are overrepresented in the research sample whilst CICs are underrepresented. No groups in the research sample formed a either a co-operative or a community benefit society. This is a reflection of when the data was collected as discussed in the previous section.

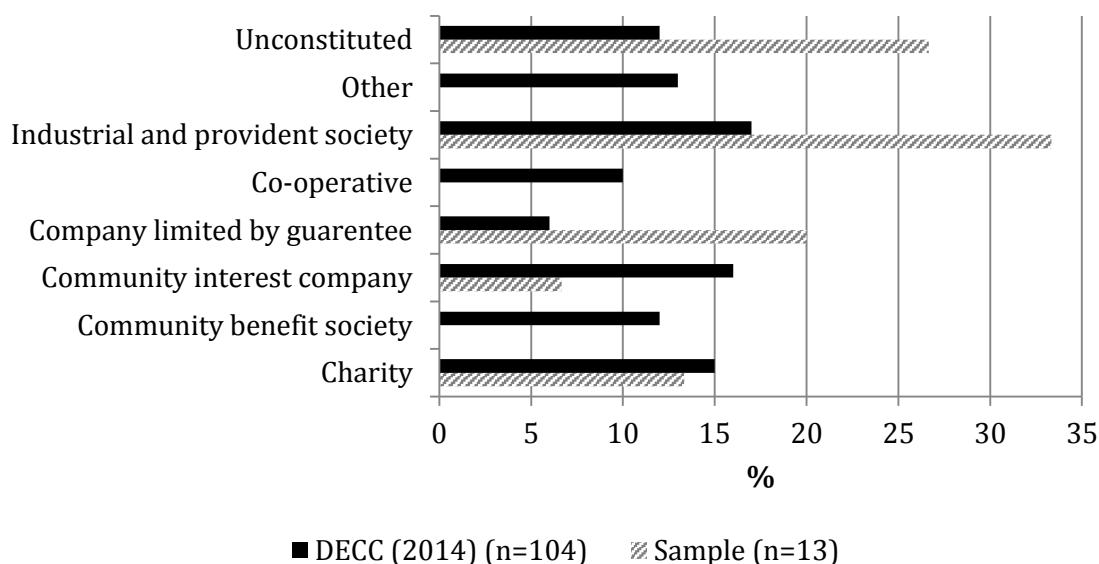


FIGURE 4-6 COMPARISON OF LEGAL STRUCTURE

4.2.1.1 Geographical distribution

The regional distribution of groups is shown in Figure 4-7. Five regions, including Scotland and Northern Ireland, are not represented in the sample. Two regions, Wales and Yorkshire and the Humber, appear to be vastly over represented, however it should be noted that the sample size is close to the number of categories and the sample therefore would be unlikely to closely match the regional distribution reported in DECC (2014e). This mismatch is unlikely to cause any substantial issues with applying the results of this study to all regions in England and Wales as policy and electricity generation are fairly consistent throughout these areas. Northern Ireland was excluded from the research because it is part of a separate electrical grid and projects therefore would have a different carbon impact. The community energy sector in Scotland has received long term support (DECC, 2014e) from funds such as the Climate Challenge Fund (Brook Lyndhurst and Ecometrica, 2011). The sector in England and Wales did not receive the same level of funding. Therefore the results of this research may not accurately represent community energy projects in Scotland.

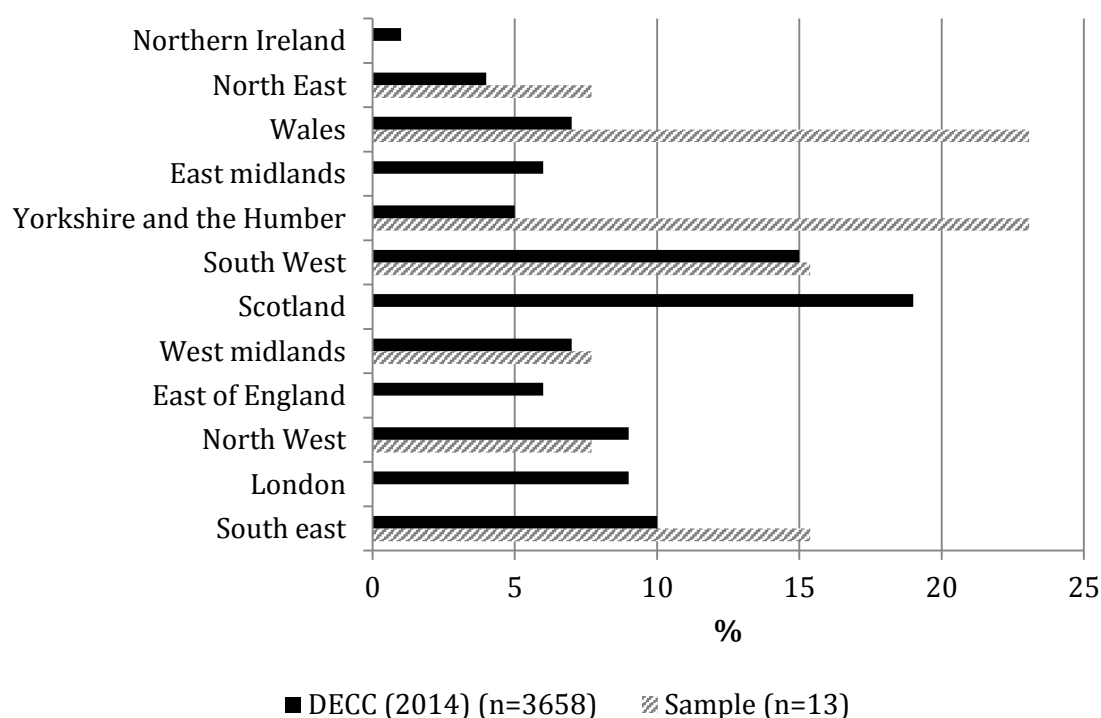


FIGURE 4-7 COMPARISON OF REGIONAL DISTRIBUTION

Rural areas are overrepresented in this research, compared to findings from the DECC (2014e) study as shown in Figure 4-8. The results shown here represent only those community groups that generate renewable energy. Only five of the groups participating in the research are based in urban areas. The other groups are based in rural towns or villages; all three groups in Wales are classified as rural villages.

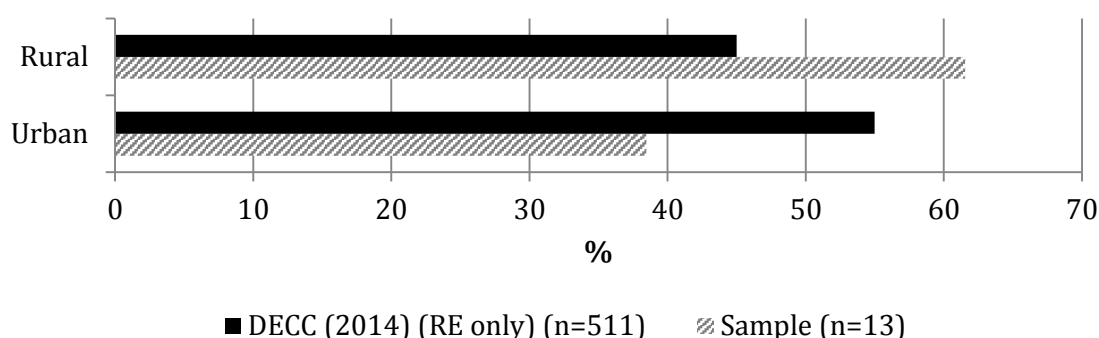


FIGURE 4-8 COMPARISON OF URBAN/RURAL STATUS OF GROUP LOCATION

Multiple indices of deprivation is a country specific metric to rank areas in order of their relative deprivation - in England this takes into account seven aspects: income, employment, health, education, crime, access to services and living environment (CLG, 2010). A comparison of the deprivation of the areas in which community renewable energy projects are taking place is shown in Figure 4-9: the ranked areas have been divided into 20% bands, with band 1 representing the most deprived 20% of areas and band 5 representing the least deprived 20% of areas. The sample only includes communities based in England as Wales has a different index of deprivation. The sample in this research represents all bands of deprivation, with the most and least deprived bands showing good correlation with those in the DECC (2014e) study. However band 4 is overrepresented in this sample.

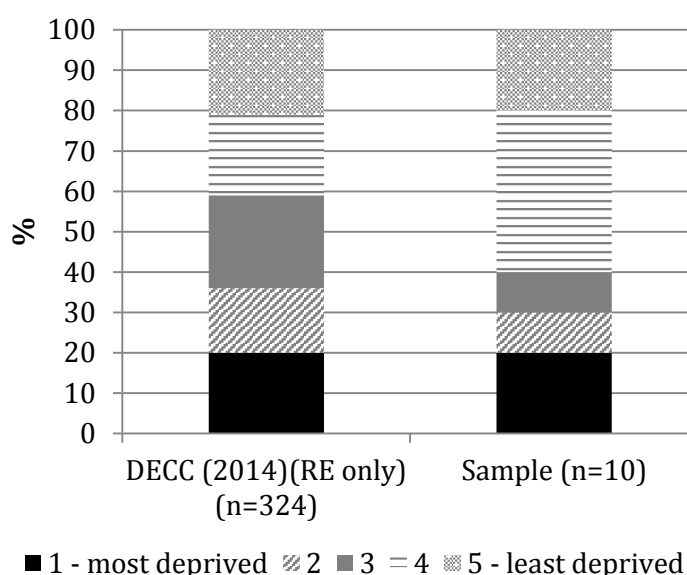


FIGURE 4-9 COMPARISON OF MULTIPLE INDEX OF DEPRIVATION (ENGLAND ONLY)

4.2.2 Community energy project

The breakdown of methods for funding projects is shown in Figure 4-10. Examples of non-grant funding includes the feed-in tariff and share offers etc. Charitable funding includes for example, company giving and philanthropy etc. The sample contains results from all 13 community groups,

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however most had multiple sources of funding. The proportion of communities receiving grant funding was lower than those receiving non-grant funding in the sample. This is the reverse of what was found in the DECC (2014e) study of all project types. However the report states that community renewable energy groups are more likely than others to utilise non-grant funding. A higher proportion of groups in the sample received charitable funding than the DECC (2014e) study. However the proportion receiving charitable funding is still below that of the other forms of funding.

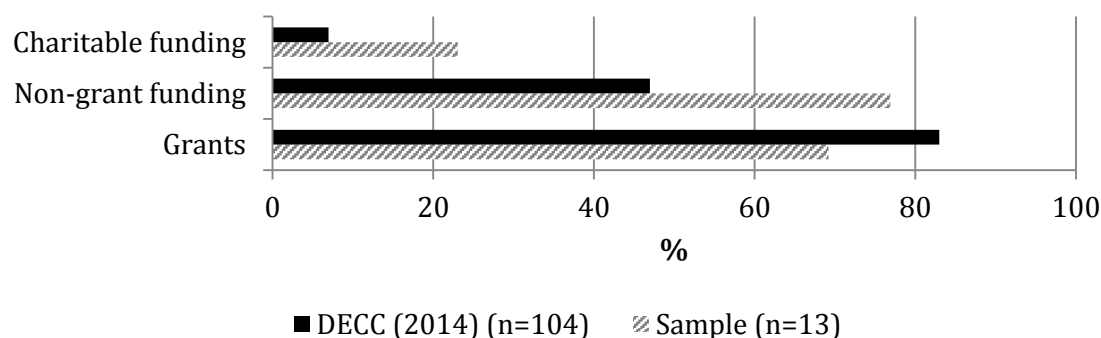


FIGURE 4-10 COMPARISON OF FUNDING

4.3 Community energy project summaries

This section presents a short introductory narrative of the 13 community groups that participated in this research. Figure 4-11 shows the locations of the groups on a map of the UK. It also shows the type of technology installed as the group's primary project. The narratives were written using data collected via interviews and via the groups' websites (Chapter 3 contains a list of these websites). In a few cases the projects were known to have radically changed since the interview took place. In these cases an additional section has been added to describe the project in its final form as it is these projects that were modelled in chapters 6-9. These data were collected from the relevant website.



FIGURE 4-11 LOCATION OF PROJECTS | COLOUR INDICATES THE PRIMARY PROJECT TECHNOLOGY TYPE | BLUE – HYDRO | ORANGE – PV | GREEN – WIND | MAP CREATED USING GOOGLE MAPS (2013)

4.3.1 Crucorney Energy Group

The Crucorney Energy group is a group in the Brecon Beacons in Wales that was established in October 2009 with the aim of reducing the carbon footprint of the community. They installed 9.8kW of photovoltaic panels on the roof of the village hall in 2011. The system cost £34,000 and was funded by a development grant from Monmouthshire county council, loans from the village hall management committee, community council, and individuals living in Crucorney. With the income they hope to purchase land to install more renewable generation on.

The Crucorney Energy Group formed after a community was inspired to take action following a presentation about micro hydro schemes by Brecon Beacon's national park staff in October 2009. The Brecon Beacon's staff hoped to enter the area for the Big Green Challenge due to its potential for micro hydro. The Crucorney Energy Group contacted the Environment Agency with a number of potential sites, but was told there was not enough manpower to check all the sites. One site eventually came back as being feasible, but the landowners were not interested. In order to participate in the Big Green Challenge the group changed their focus to community involvement and held several public meetings promoting energy knowledge with the aim of reducing the carbon footprint of the community. The announcement of the feed-in tariff gave the impetus to the group to install the photovoltaic system on the village hall. They were then successful in a grant application to develop a charcoal making industry, which led them to set up a woodland group. This group produces a limited amount of charcoal, from the woodland, that is sold at the local garage.

The group is currently run by a core of around six people with a further six people regularly attending energy meetings. The group also runs an allotment group and this currently has around 40 people. There has been a drop in enthusiasm with fewer people taking part in the planned activities and the public meetings. However people new to the area do get involved with the group.

The system is grid connected and any excess electricity generated by the photovoltaic panels is exported to the grid. At the moment the village hall is not used much during daylight hours and a high proportion of the electricity generated is exported. The group is investigating purchasing an electric car to start a car club in the area, which could make use of the electricity generated during the day.

TABLE 4-1 SUMMARY OF CRUCORNEY ENERGY GROUP COMMUNITY ENERGY PROJECT

Characteristic	Village Hall
Technology	PV
Installed Capacity (kW)	9.8
Idea (approx.)	March 2010
Installed	March 2011
Approx. cost	£34,000
Core members	6
Supporters (approx.)	12

4.3.2 Easton Community Centre

Easton Community Centre in Bristol was built in the 1990s by members of the community. It is currently owned by Bristol City Council and is leased by the Easton Community Centre who aims to retain the building for community use. The centre has 3 separate photovoltaic systems with a combined installed capacity of 18kW. These were installed in July 2012 and were funded by a local cooperative: Bristol Energy Cooperative.

The Bristol Energy Cooperative was established in 2011 with the objective of addressing problems with the energy system by investing in renewable energy and energy efficiency projects to help the local community. They launched a share offer in 2012 to raise money to install photovoltaic systems on community buildings. Over 150 individuals invested to raise a total £128,000 which was split over three community centres in Bristol, including Easton Community Centre, who had been approached by Bristol Energy Cooperative.

Before the project could proceed, a financial agreement had to be reached between the three parties with interests in the centre: Easton Community Centre, their landlords - Bristol City Council and Bristol Energy Cooperative. Bristol Energy Cooperative funded the installation of the system and receives all the income from the feed-in tariff and export. Easton Community Centre pays to rent the photovoltaic systems and receives free electricity from the systems. The centre was assured that they would save money due to the project.

The community centre is interested to save money on energy bills in order to keep the centre open for the community. The rent for their four tenants includes a set rate to cover energy and water bills. The centre managers feel that there is therefore no incentive for the tenants to reduce their energy use.

The centre are also keen to make full use of the free electricity and would like to offer extra classes, for example cooking classes which use a lot of electricity, at times the PV systems are generating excess electricity. However the centre are unable to identify when excess electricity is generated as they need to monitor three separate circuits. The building had three separate circuits supplying grid electricity to the building, each circuit is also feed by one of the PV systems. The energy infrastructure in the building is an antiquated system using domestic parts and these need to be upgraded before the centre's electricity use can be fully understood.

TABLE 4-2 SUMMARY OF EASTON COMMUNITY CENTRE COMMUNITY ENERGY PROJECT

Characteristic	Village Hall
Technology	PV
Installed Capacity (kW)	18
Idea (approx.)	July 2012
Installed	July 2012
Approx. cost	£37,000
Core members	8 (6 BEC, 1 BCC, 1ECC)
Supporters (approx.)	4

4.3.3 Green Transition Eynsham Area (Green TEA)

Green TEA is part of the transition movement and is based around Eynsham in Oxfordshire. It was established in 2009 to help the community transition to a sustainable lifestyle. Two photovoltaic systems were installed in 2012, one on the village hall and one on the local catholic church. A third system had been planned, however the financial situation of the building changed and they were able to self-fund. The projects took two years to develop and complete. The systems were financed as a pilot scheme for a large project, “The People’s Power Station”, coordinated by the Oxfordshire Low Carbon Hub. This was a project envisioned to replace Didcot Power Station with community owned renewable energy. Although the pilot was successful, the business model is no longer viable due to feed-in tariff changes.

Green TEA is comprised of around 50 people split evenly across five working groups: challenge, energy, food, transport and waste. The energy group run activities based around two themes, Powering Down and Powering Up. Powering Down encourages the community to reduce its energy use whilst Powering Up encourages the community to install renewable energy generation. Activities range from energy saving information and demonstration, educational projects, energy assessments and thermal imaging to installing renewable energy on community buildings. Some of this work was financed through a £40,000 Local Energy Assessment Fund (LEAF) grant. Although they feel that this range of activities has reached and motivated a wide range of people, it comes with a high work load.

The buildings receive free energy from the photovoltaic systems and so their running costs should reduce. The feed-in tariff initially goes to the Oxfordshire Low Carbon Hub to pay off the loan that paid for the scheme. Once that is paid off the surplus from the village hall goes to the village hall. The surplus from the church will be split between the Oxfordshire Low Carbon Hub and Green TEA. Green TEA plan to use this income to continue energy saving work, possibly using it as match funding in grant applications.

TABLE 4-3 SUMMARY OF GREEN TEA COMMUNITY ENERGY PROJECT

Characteristic	Village Hall	Church
Technology	PV	PV
Installed Capacity (kW)	12.65	4
Idea (approx.)	October 2010	October 2010
Installed	July 2012	March 2012
Approx. cost	Unknown	Unknown
Core members	10	
Supporters (approx.)	50	

4.3.4 Hebden Bridge Town Hall

Hebden Bridge Town Hall was acquired by the Hebden Bridge Community Association (HBCA) in 2010 through an asset transfer from Calderdale Local Authority. The main aim of HBCA was to redevelop an underused building and provide suitable space to support the activities of the local community for the benefit of the whole community. Groups hosting events that are for the benefit of the community are offered the spaces at a reduced rate.

HBCA raised £3.7 million to develop an expansion to the original 1890s building. To gain planning permission, this extension had to meet BREEAM very good standards and provide 15% of energy from low or zero carbon technologies. HBCA were very supportive of these conditions and are committed to being green. Concern over future costs of electricity and creating a sustainable business plan supported installing energy generation in the building. The condition of 15% energy generation has been met with gas fired combined heat and power unit (CHP), 12m² solar thermal and 24 m² photovoltaic (PV) panels.

A local organisation, the Alternative Technology Centre, worked with HBCA to develop a feasible plan for energy development. A range of technologies were considered including a reverse Archimedes screw and a heat exchange from the river which runs alongside the building. Although some members of HBCA were keen for the building to be an exemplar green building, the financial sustainability of the building was a higher priority. Public meetings were held during the development of the extension.

HBCA consists of 10 trustees elected by their members. There are around 600 members known as Friends of the Town Hall; these are individuals who donated £10 or more to HBCA to support their efforts to acquire the Town Hall and for its development. The Town Hall is run by four members of staff who are supported by a further 25 volunteers.

Both the CHP unit and PV system are grid connected and excess electricity is exported. HBCA receive the income from feed-in tariff and from selling exported units. This is used to keep the building running.

TABLE 4-4 SUMMARY OF HEBDEN BRIDGE TOWN HALL COMMUNITY ENERGY PROJECT

Characteristic	Town hall
Technology	PV
Installed Capacity (kW)	4
Idea (approx.)	June 2010
Installed	June 2012
Approx. cost	Unknown
Core members	14
Supporters (approx.)	625

4.3.5 Hexham river hydro

Hexham River Hydro is a joint initiative between Transition Tyndale and Hexham Community Partnership based in the North-East of England. It was formed in 2010 with the objective of installing hydro power on the River Tyne. It plans to install a reverse Archimedes screw with an installed capacity of 100kW.

Hexham River Hydro grew out of the transition town group, Transition Tyndale. Transition Tyndale at first investigated wind generation. When this was ruled out due to a lack of community owned land, attention moved to the river as a potential location. Members from Transition Tyndale contacted Hexham Community Partnership, a group who work to improve Hexham for the community. An informal partnership of six people was formed between the two groups to develop

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a hydro project on the river. They hoped that this project would provide a number of benefits: reduce carbon emissions, income stream to the community, education, community engagement, enhance the river and tourism.

In December 2011 they won £100,000 from an Energyshare competition, supported by British Gas and Carbon Leapfrog. The money was awarded to the group who gained the most supporters on the Energyshare website. Hexham River Hydro gained over 3800 supporters, beating city based groups. The money was used for development of the project such as the detailed design work and hosting of public meetings. Separate meetings were held for the general public and for anglers, who had raised more specific concerns about the project. Facilitators were used at the meetings to ensure that Hexham River Hydro addressed concerns raised.

The intention is to form a community interest company (CIC) to manage the day to day needs of the hydro project once it is active. The CIC would have a new board of directors with the skills required to maintain a project. The income from the feed-in tariff and electricity sales would go to the Hexham Community Partnership who would provide the CIC with enough money to cover shares and maintenance etc. Hexham Community Partnership would use any surplus to continue their work in the community and to run the educational program associated with the hydro project.

4.3.5.1 Update

Three years after development started a detailed design study estimated the cost of the project would be approximately £2.1 million, twice the original estimate. The cost at this stage for two reasons. The Environment Agency requires fish passes to be built alongside hydro projects, when the design was started a different group were already working on installing a fish pass. When this group pulled out the responsibility and cost passed to Hexham River Hydro. It became apparent at this stage that repair works would need to be carried out to the weir and associated infrastructure before the project could be installed. The local authority were unable to cover the costs of repair so Hexham River Hydro included the costs within the project. Hexham River Hydro felt the risks involved with a project of this cost were too high for a community group to undertake. Therefore the project was abandoned as a community project.

TABLE 4-5 SUMMARY OF HEXHAM RIVER HYDRO PLANNED COMMUNITY ENERGY PROJECT

Characteristic	River weir
Technology	Reverse Archimedes screw
Installed Capacity (kW)	100
Idea (approx.)	January 2010
Installed	Abandoned
Approx. cost	£2.1 million
Core members	6
Supporters (approx.)	3884

4.3.6 Llangattock Green Valleys

Llangattock Green Valleys (LGV) is a community interest company based in the Brecon Beacons, South Wales. They have a business arm: LGV ventures which deals with purchasing and selling of energy generation technology. They aim to help the community become carbon negative by 2015, by becoming a net exporter of renewable energy. They aim to generate sustainable energy, improve local sustainability and educate the community with strong involvement of the community. LGV is run by six directors and a mailing list of 256 members

The seed for LGV was the same as for the Crucorney Energy group: Brecon Beacon's national park staff and The Big Green Challenge. Llangattock Green Valleys applied to and were accepted on to the community version of British Gas Green Streets competition. They were the Welsh regional finalists on the strength of their micro hydro development, community involvement and development of a local wood fuel. They had a year of undertaking community involvement activities and were given £137,000 of match funding to put their business plan into action. Energy efficiency measures were installed in 38 homes and PV systems in 12 homes. The school had insulation put in and a 4.32kW PV system. The school benefits from the feed-in tariff and from free electricity. The community hall had an air source heat pump installed and a borehole and electric pump powered by a PV system were installed at the community allotments to provide water. They were crowned the winners of the competition in 2011 and were awarded a further £100,000 which has been invested in developing micro-hydro schemes.

LGV were keen to continue the efforts that had been made during the Green Streets competition and went about creating an online Energy Audit. There were 37 users by the end of 2012 after an initial drop at the end of Green Streets. Households in the community can enter monthly meter readings, non-metered energy usage and PV and solar thermal generation online. The audit then calculates their energy usage and carbon savings and allows them to compare this against their previous statistics. They also publish open access graphs showing average energy use and average carbon emitted per household and the total renewable energy generated and carbon saved per year. There is a diverse range of energy sources used in Llangattock, which increases the difficulty of collecting energy use data. They were awarded £5000 from the Small Lottery for the development of the online Energy Audit.

TABLE 4-6 SUMMARY OF LLANGATTOCK GREEN VALLEYS COMMUNITY ENERGY PROJECT

Characteristic	School
Technology	PV
Installed Capacity (kW)	4.23
Idea (approx.)	September 2009
Installed	January 2011
Approx. cost	Unknown
Core members	6
Supporters (approx.)	355

4.3.7 Low Carbon Gordano

Low Carbon Gordano is an Industrial and Provident Society for community benefit based in the northern part of North Somerset. It was formed in 2010 to reduce energy costs and reduce the local carbon footprint. They have proposed a number of schemes. The most developed project is a 150kW ground-based photovoltaic array on a local farm. This £250,000 project would be financed through a community share offer. A small portion of finance raised through the offer would be put straight into a community benefit fund to provide an immediate benefit to the surrounding area.

Two groups with a common interest in energy were the starting point for Low Carbon Gordano: Transition Portishead and Sustainable Pill. Members from these two groups met at a workshop about setting up a community energy plan and decided that they would each be more successful if they joined forces. Low Carbon Gordano was founded by a group of three directors. They've grown to having a board of five directors and a further five people who are actively involved. They have a mailing list of around 550 people which includes those who supported the original two groups. A pioneer share issue raised £6,000, a portion of what was hoped for, to be used for core funding such as supporting planning applications.

In October 2011 feed-in tariff rates were halved, just as Low Carbon Gordano were to issue a share offer to raise the finance required to install solar schemes on six schools and community buildings. These projects were halted as they were no longer financially viable. Since this point the group have been working to re-establish themselves. They are working on several projects aside from the farm solar array, including a project to create a school service contract combining improving lighting efficiency and photovoltaic provision. They also run an energy advice service, EASY, which was financed by a LEAF grant awarded in 2012.

Low Carbon Gordano are keen to use a financially sound business model and feel that the returns from the feed-in tariff alone are not enough to provide this. Therefore the group plan to sell the electricity to the land owner at a reduced price for additional income. The land owner would then benefit from a reduced price for electricity and income from a fixed rental for the land. Surplus electricity will be supplied to the grid.

4.3.7.1 Update

In October 2013 planning permission was turned down after 12 months of project development. However the group went on to develop a similar project at another farm. This project has a much larger planned installed capacity. The group have raised the required finance for the project through a community share offer. Construction was underway by December 2014. This is the project that is modelled in this research.

TABLE 4-7 SUMMARY OF LOW CARBON GORDANO PLANNED COMMUNITY ENERGY PROJECT

Characteristic	Private farm
Technology	PV
Installed Capacity (kW)	1875
Idea (approx.)	November 2012
Installed	Planned
Approx. cost	£2.2 million
Core members	5
Supporters (approx.)	555

4.3.8 OVESCO

OVESCO is an Industrial and Providence Society based in Lewes in the South-East of England. It was founded in 2007 to promote energy saving and renewable energy in order to reduce the fossil fuel use of the area. They raised over £350,000 through a community share offer, more than they needed. This share offer was used for four PV systems: a local company, a school, a farm and a plant nursery. They are currently attempting to raise funds for another PV project on a school through a community share offer.

Transition Town Lewes energy group were the seed for OVESCO. Concern over climate change was high in Lewes likely due to local flooding. OVESCO administered a renewable grant scheme and ran an energy advice line for Lewes District Council for two years until the funding was cut in 2012. The group have investigated both hydro and wind schemes. However the risks were felt to be too high to pursue further; country wide opposition to such schemes combined with the large costs incurred before installation starts increases financial risks for community energy groups. OVESCO were awarded two LEAF grants. One was used for a feasibility study of a district heating CHP system. Although it was relatively easy to install and had the right mix of users to work optimally the cost was thought to be prohibitive. The other LEAF grant was awarded in connection with another group and was used to identify potential sites for PV systems. As a result of this OVESCO were considering a £1 million ground solar array project. This size of project would provide the group financial stability. However grid connection costs would add around another £600,000 to the project.

OVESCO has a board of five directors. One director is employed on a part time contract. However they work full time for the group. There are around 250 shareholders with some of the shares held for children. The most shareholders are based locally, with the remaining shareholders being linked to the area.

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The first project was installed in July 2011 on the warehouse of a local community minded company. They get free electricity and a peppercorn rent. OVESCO receives income from the feed-in tariff and from energy export. The income from the energy export is less than had been anticipated partly due to an increase in the buildings energy consumption. Due to the system size, the project has to be registered directly with OFGEM, which complicates the process. OVESCO intends to create a community benefit fund once they have paid off some of the shares and are financially stable.

TABLE 4-8 SUMMARY OF OVESCO COMMUNITY ENERGY PROJECTS

Characteristic	Local company	School	Farm	Plant nursery
Technology	PV	PV	PV	PV
Installed Capacity (kW)	98	35	19.5	9
Idea (approx.)	July 2010			
Installed	July 2011	June 2012	July 2012	July 2012
Approx. cost	£350,000			
Core members	5			
Supporters (approx.)	250			

4.3.9 Pennine Community Power

Pennine Community Power (PCP) is an Industrial and Provident Society for community benefit based in Blackshaw Head in the north of England. It was set up in April 2012 with the aim of helping create an environmentally, socially and economically sustainable community through the generation of renewable energy. In October 2012 they installed a 10kW wind turbine using funding from a combination of Lottery funding and a community share offer. The wind turbine is a single phase turbine as Blackshaw Head is a rural area with a single phase electricity supply

The Blackshaw Environmental Action Team (BEAT) was the seed for Pennine Community Power. BEAT formed in the 1990s as an environmental group. In 2010 the focus of this group developed into sustainability issues, such as climate change. Their activities are based around energy and food. As part of their energy activities they developed two projects that developed through to installations: a solar thermal project which attracted 10 households to participate and a community owned wind project. The intention of the project was to provide an income stream through the feed-in tariff to fund other community energy projects in the community. Wind was selected as the group felt that the location situated on top of the moors in the Pennines would enable high returns for the required investment. In order to issue a community share offer to finance the project Pennine Community Power was set up as a separate entity.

Development of the project was undertaken mainly by the four directors that had founded the IPS. Although they organised public meetings to enable the wider community to input into the design, they were not well attended – approximately 10 people attended. However a party held to launch the share offer was well attended. The share offer raised more money than required and there are currently 65 shareholders: 64 shareholders live within a few miles of the project, one lives within the same local authority area. During the first AGM, held shortly after the turbine

was connected to the grid, a further two directors were added to the board to increase its size to six members.

The wind turbine was installed on land owned by a neighbour of a PCP director. Rather than paying the landowner rent, the landowner receives free electricity from the wind turbine.

TABLE 4-9 SUMMARY OF PENNINE COMMUNITY POWER COMMUNITY ENERGY PROJECT

Characteristic	Private land
Technology	Wind
Installed Capacity (kW)	10
Idea (approx.)	January 2012
Installed	October 2012
Approx. cost	£60,000
Core members	6
Supporters (approx.)	65

4.3.10 Sheffield Renewables

Sheffield Renewables is an Industrial and Providence Society based in Sheffield that formed in 2007. They developed two hydro schemes, one smaller scheme based in the city centre and a larger scheme near the outskirts of the Sheffield area. They raised a share offer of £250,000 and negotiated loans of £350,000. However this did not cover the quoted price of £850,000 following a last minute decision by the Environment Agency that the larger scheme must include two fish passes. The group are now looking to use the share offers to install solar PV on community buildings, although 5 investors have withdrawn their money, stating that their primary interest was with hydro power.

Sheffield Renewables are a spin off group from a campaign organisation, Sheffield Against Climate Change. They formed out of a desire to make physical changes in Sheffield rather than focusing on campaigning. The aim of Sheffield Renewables is to reduce emissions of CO₂ and to generate renewable energy. They initially focused on hydro schemes due to Sheffield's history: women used to sharpen knives from the cities steel industry using water powered grinders. A student at one of the universities carried out a feasibility study of where hydro generation could be sited in Sheffield and they held their first public meeting in 2008. In 2009 they were awarded core funding from the local council to help them become established. With this they funded an office and a project manager. The group have a core of between 8 to 10 people developing projects, who are supported by around 20 to 25 active volunteers, carrying out specific tasks. They also have 1,500 people registered on their website to show their support of the projects. They recruit through local festivals which they attend, demonstrating how renewable energy works and a bicycle generator powering a light bulb to demonstrate how much effort is required.

The smaller scheme was planned to be installed at Kelham Island, where historically a water wheel had been situated. The scheme would be next to the industrial museum and there were plans to link to the museum to provide an educational experience. The project was put on hold by the group because they felt they did not have the resources to fight a campaign that was started against the

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project by individuals concerned about the ecological impact of the project, particularly to fish. The group later received interest from a green housing developer to take over the project.

The site of the larger scheme was Jordan's Dam on the border between Rotherham and Sheffield. A power purchase agreement was created: Yorkshire Water would buy the electricity at a lower than commercial rate and in return would lease the land to Sheffield Renewables for a minimum rent. The income from the two schemes would be used to pay off loans and shares with a 3% return on investment, with the remaining money being reinvested into the next generation scheme. Although the solar PV is at a very early stage of development, the money may be used for a community benefit fund.

TABLE 4-10 SUMMARY OF SHEFFIELD RENEWABLES PROPOSED COMMUNITY ENERGY PROJECTS

Characteristic	River weir (remote)
Technology	Reverse Archimedes screw
Installed Capacity (kW)	80
Idea (approx.)	November 2008
Installed	Halted
Approx. cost	£850,000
Core members	10
Supporters (approx.)	2775

4.3.10.1 Update

In April 2014 a 50kW PV system was installed on a community building in Sheffield. The project was funded through the original share offer. The group are planning to install other PV systems of a similar size in the city.

TABLE 4-11 SUMMARY OF SHEFFIELD RENEWABLES COMMUNITY ENERGY PROJECT

Characteristic	Community building
Technology	PV
Installed Capacity (kW)	50
Idea (approx.)	April 2013
Installed	April 2014
Approx. cost	£60,000
Core members	10
Supporters (approx.)	2775

4.3.11 Snitterfield Actioning Climate Change

Snitterfield Actioning Climate Change is a group of residents, based in the village of Snitterfield, which formed in 2007. They installed 3.6kW photovoltaic systems on the village hall and sports club in December 2011 and on the primary school in July 2012. This was funded by local businesses and by a deal with a solar installer: they would donate one 2kW photovoltaic system for every 10 households in Snitterfield that used them. When the deal finished, 36 households had installed photovoltaic systems.

The group formed following a request from the Parish Council to five individuals in the area to set up a community green group. The group that formed felt that they should be representative of the village and so held a launch event with the aims of getting more people involved and to find out what the village needed. The event had a good turn out; 1 in 6 people in the village attended. The group expanded to eight members and were asked to focus on the school and village hall.

Prior to the photovoltaic project the group carried out a large number of activities based around the school and the village hall: set up an eco-group at the school, set up a recycling scheme based at the village hall, set up a discount deal for low energy light bulbs, researched green tariffs and encouraged around 15 households to switch tariffs, etc. They raised funds through bring and buy sales. They received funding from the West Midlands Chamber of Commerce to survey community buildings to identify energy efficiency improvements. At a public meeting to discuss the outcome of the survey, the group were asked to focus on the school and village hall. Funding from the Energy Savings Trust was used to research setting up a community photovoltaic project: they helped the group put a photovoltaic project out to tender to 20 solar installers. The top two installers were invited to present their business at an open meeting where the village voted for their preferred installer. The village voted for the cheaper installer, who was subsequently persuaded by the group to offer the deal to donate a system for every 10 households. The group have also been awarded a DECC grant to carry out a study on the viability of small wind. They have commissioned a local company to carry out a wind assessment of the local area.

All three community buildings benefit from the free electricity generated by the photovoltaic systems. The school also receives the feed-in tariff from its system, however this must be spend on green activities. The feed-in tariff from the village hall and sports club is used for a community fund for green activities that anyone in the community can apply for.

TABLE 4-12 SUMMARY OF SNITTERFIELD ACTIONING CLIMATE CHANGE COMMUNITY ENERGY PROJECTS

Characteristic	Village hall	School	Sports club
Technology	PV	PV	PV
Installed Capacity (kW)	3.6	3.6	3.6
Idea (approx.)	October 2010		
Installed	December 2011	July 2012	December 2011
Approx. cost	£2,000	£0	£2,000
Core members	8		
Supporters (approx.)	37		

4.3.12 Talybont on Usk Energy

Talybont on Usk Energy is a company limited by guarantee formed in 2004 based in the Brecon Beacons. They aim to reduce energy consumption and increase renewable energy generation. They installed a 36kW hydroelectric turbine at a local reservoir in 2006, the first community hydro scheme in Wales. The project cost around £90,000, which was funded through a series of grants. In 2011 Talybont Energy funded the installation of 4kW of solar PV on the village hall using the income generated from the hydro project.

THE CARBON SAVING POTENTIAL OF COMMUNITY RENEWABLE ENERGY IN THE UK

Talybont on Usk Energy formed from a group of locals who became interested in hydro power in 2001. A feasibility study in 2003 identified an old hydroelectric turbine that had been switched off when mains electricity was bought to the area. Following three years of negotiation and fund raising a new turbine was put in place and switched on in 2006 – the rest of the infrastructure was already in place. The electricity from the project is sold to the national grid to maintain a sense of fairness; the energy produced could not supply the whole village. Although the turbine was installed prior to the introduction of the feed-in tariff scheme, an exemption has been made so that the project receives payments under the scheme. Around one quarter of the income is spent on insurance and maintenance, the remainder is spent on community projects. These community projects must have an environmentally sustainable element and must benefit the whole community, i.e. not individuals or businesses. Projects are suggested by the community, the directors of the company filter them against their criteria and then a panel with members from the community and a director select which projects are funded.

Projects which have been funded include a biodiesel and electric car club and installation of PV on the village hall. The village hall gets free electricity and half the FiT income for the first 10 years, with the other half going to Talybont Energy to recoup their investment. Talybont on Usk Energy also run an educational programme in primary schools to encourage children to think about their energy use, by demonstrating renewable energy technologies – the programme was written to fit in with the national curriculum.

The board of directors consists of eight members, only the chair and secretary have been in place since the group formed. Most of those involved whilst the project was being designed and implemented have since either moved away or lost interest as the project has moved from an engineering to a social focus. Only around 15 to 20 members of the community are felt to be engaged with the work of Talybont on Usk Energy.

TABLE 4-13 SUMMARY OF TALYBONT ON USK ENERGY'S COMMUNITY ENERGY PROJECT

Characteristic	Reservoir dam
Technology	Hydroelectric turbine
Installed Capacity (kW)	36
Idea (approx.)	February 2003
Installed	April 2006
Approx. cost	£90,000
Core members	8
Supporters (approx.)	15-20

4.3.13 Whalley Community Hydro

Whalley Community Hydro is an Industrial and Providence Society for community benefit based in Whalley, Lancashire. The aim of the group is to reduce carbon emissions and raise awareness about reducing carbon emissions. They are developing a 100kW hydro project on the River Calder on privately owned farmland adjacent to a weir. The project is to be funded through bank loans and a share offer, with a rate of return between 3 and 5%. Profit from the project would be used to carry out further projects, such as PV or to provide start up grants to sustainable businesses, i.e. electric

bike hire. They hope the project will have an educational aspect and plan to invite school parties to visit, put in a display board and maintain an informative website. The electricity will be exported to the national grid.

Transition Town Clithero formed in 2009 and started a group looking at potential energy campaigns in the area. In 2010 a small group, who wanted practical action attended a workshop about hydro power, which empowered them to form a separate group to look at the potential of hydro in Whalley. Planning permission was granted in February 2012, having received 30 letters of support from local residents and businesses. The group were awarded grant for £20,000 from DECC which funded an external company to carry out the design study. It has been estimated that the maximum power generation from the river would be 110kW, however it is planned to install 100kW of generation because this is the top of one band of the feed-in tariff scheme. Access negotiations with the land owner and households along the route have extended the process and as yet all parties are yet to sign the agreements.

Whalley Community Hydro is comprised of 4 members who keep the project running. They have had some interest in helping from other residents of the community, however have struggled to include them, due to the close knit relationship between the core members.

4.3.13.1 Update

Whalley Community Hydro launched a share offer in November 2013. They started work to install the Archimedes screw in May 2014 and generation at the site started in November 2014.

TABLE 4-14 SUMMARY OF WHALLEY COMMUNITY HYDRO COMMUNITY ENERGY PROJECT

Characteristic	River weir
Technology	Reverse Archimedes screw
Installed Capacity (kW)	100
Idea (approx.)	February 2010
Installed	November 2014
Approx. cost	£75,000
Core members	4
Supporters (approx.)	30

4.4 Summary

The sample of community groups in this research is focused on one subsection of the sector. The aim of the research is to evaluate the carbon saving potential of this subsection of the sector. Therefore a single-community study would not be appropriate as although the community would be studied in more depth, the breadth of the sector would not be apparent. A multi-community study, although covering each community in less depth allows the breadth of the sector to be examined. See Chapter 3: Methodology for details of how the communities were recruited. The sample size is comparable to that of other recent multi-community studies, i.e. LCCC evaluating 22 communities (DECC, 2012d), BGC evaluated 10 communities (Brook Lyndhurst, 2010) and the British Gas Green Streets community energy challenge evaluated 14 communities (Platt et al., 2011).

The some aspects of the community groups profile of the research sample is different to that reported in the DECC (2014e) study. The sample does not include examples of all legal structures – however the sample was made prior to creation of some structures. The sample does not cover all regions. It does however include projects from both England and Wales and projects from both the north and the south of England. Therefore it is felt the results of the research will be applicable to all of England and Wales. Community energy projects based in rural areas are overrepresented in the research sample.

There is no single developmental pathway or model for community energy projects in a sector with rapid development. There appear to be two types of community energy project installing renewable generation emerging: projects where technology is installed on a community building or land through collective action and projects where individual households have installed technology within a community framework. This research has focused on the former type of community energy project, although there are some community groups that have carried out both types of project or where the distinction is blurred.

A range of activities are being carried out by the groups, including some without a direct link to the energy system, i.e. community gardens. The survey responses indicate there is a large variation in the number of unique activities per group, zero to ten. Comparison of the responses to with interview data suggests that some groups underreported activities in the survey. An analysis of the activities could suggest that thermal imaging is being used as an educational tool rather than an evaluation tool.

Solar PV systems are more commonly installed by community groups than other types of technology. However the number of hydro projects at the planning stage could indicate they are growing in popularity. In Chapter 2: A Review of the Literature it was identified that the install rate of solar PV systems had increased in the UK due to the FiT scheme, however the case study summaries suggest that other factors have influenced technology choice, this echoes evidence from Platt et al. (2011) and DECC (2012d) suggest that in a community setting, other considerations i.e. visibility may affect technology choice. An investigation of the reasoning behind technology choice will be reported in Chapter 5 – a qualitative analysis of project development and outcomes.

CHAPTER 5 PROJECT DEVELOPMENT AND OUTCOME

This chapter presents a qualitative assessment of interviews conducted with representatives of thirteen community energy groups, carried out between November 2012 and April 2013. The method of data collection and data analysis is presented in Chapter 3. The objective of this qualitative assessment is to examine why certain courses of action are taken during the delivery of a community energy project. This is used to inform the boundaries of the LCA and the context in which it is analysed.

The analysis is presented in five sections. The first section focuses on the community group responsible for delivering the community energy project. The second section looks at the decisions taken and why they were taken during the development and delivery of the project. Section three evaluates how the income is distributed and why. Section four is an assessment of community engagement. The final section looks at how external bodies have affected the project.

5.1 Community group

This section presents an evaluation of the community group. It covers how and where these groups have formed and what their aims are. It also looks at the makeup of the group.

5.1.1 Aims

The main aim of the majority of groups was to reduce carbon emissions from their community. Although this finding may be due to bias introduced in the recruitment phase (see Chapter 3), it aligns with results from other studies of the sector. Groups which formed in 2010 or later, appear to have three distinct aims: carbon reduction, income stream and energy education. Groups that formed prior to 2010 have a wider variety of aims: carbon reduction, energy education, community ownership, energy generation, reduction of fossil fuels, and action by households. Although many also use the income stream they gain from the feed-in tariff for similar purposes as post 2010 groups, during interview it did not appear to be a core aim of the group to do so.

Not all community groups formed because of energy or environmental reasons although such groups are atypical. The aim of these groups is also atypical. One group formed because of local engineering interest in a specific technology, hydro power. Subsequent to the installation of the project, many of the original volunteers lost interest or moved away. However the community group continues to run the project, but the focus has changed to educating the community on energy issues. Other groups have formed around the idea of creating a financially and environmentally sustainable community space. The overriding aim of those groups creating community space is to future proof to ensure cheap provision of energy for the space. However the interviewees were also interested in the reduction of their carbon footprint.

5.1.2 Formation

The majority of community groups were either the energy group of the local transition town, the local environmental group or had split from one of these groups. The energy group in the local transition town or other groups with an environmental focus were the basis for the majority of community energy projects in this sample. Local flooding was suggested to have provided a focus for a number of these environmental groups to form. The high proportion of groups forming from transition towns in this sample may be due to bias introduced in the recruitment phase (one source of recruitment was a website devoted to transition groups, see Chapter 3) rather than being typical of the sector.

The splits typically occurred at two points: when the idea for the project began to develop or around the time that the project needed to be financed. Community groups that had formed around the later point tended to have done so for legal reasons, i.e. to become a legally recognised structure that could issue a share offer. Those that had formed around the former point had tended to do so because of a desire for practical action. These interviewees typically acknowledged that the transition town movement or equivalent was the seed for the group to develop. However they frequently went on to distance themselves from the original group, highlighting how the two groups were distinct.

“But many people will say in the environmental movement ... you get a lot of people who are just not very practical you know, they’re not very organisational minded, they don’t really have the experience of running projects, you know starting something and seeing it through to fruition so you see a lot of theoretical ideas about, ... I don’t want to knock ideals at all, they’re very important, but without the practical experience, life experience they don’t know how to move things ahead so they sit and talk and talk and talk, you know interminably, I mean as I say I don’t want to knock them, because their hearts in the right place, they want to do the right thing, they’re keen and so on, but I’m impatient, I want to get on, I want to do it, I want some action” – Interviewee 13A

The remaining groups show some variety in routes to forming a community group to undertake a community energy project. Several groups in one area formed in order to participate in a competition about energy. An external individual was instrumental in inspiring these groups to participate. However despite one group not being able to fully participate in the original idea both groups are still running. Another group was formed when the local council selected a few individuals in the area and asked them to look at environmental issues in the community.

5.1.3 Community boundaries

The groups in the sample cover areas with very different geographical and population sizes. The common factor appears to be the number of individuals heavily involved with the project – the core group. In the sample the size of the core group was between 4 and 14 individuals with no correlation to the boundary area covered. One interviewee commented that their group had expanded to cover a very large area because they felt the communities within that area were all too small to provide enough individuals to support a community energy project. Another group had focused on a very specific small area in order to form a smaller core group that were focused on one purpose.

“well, we’re a big group, I mean [name], well it’s not just [name] it’s [name] Area and [name] is quite big, ... and then all the surrounding villages so I guess our reach is very patchy and I think mostly it’s people who have an interest anyway” – Interviewee 03A

One interviewee discussed one local group that had changed its name to ensure that it reflected the area it hoped to cover. Nearly all of the community groups have names that identify the location in which they are based. These locations frequently correspond to specific build up areas, i.e. a village or city, however the area covered is often wider than the boundary around the built up area. However some of these groups have gathered members from a wide region.

Other names however refer to a larger area with poorly defined boundaries. This may have been to increase the impact they could have or the number of core people that were involved from each area. Other reasons may have been to distinguish the group from existing groups in the area or perhaps to make the group sound more grandiose so activity would be taken seriously.

Although atypical, not every name linked to an area. This is due to evolution of the name, first becoming abbreviated and then the abbreviation becoming the full name. This will potentially affect the ability of these groups to link to the local community. However the representatives of most of these groups commented that the majority of their shareholders were local to the area.

5.1.4 Legal structure

The largest number of groups in the sample had a formal structure in the form of Industrial and Provident Societies (IPS). Groups frequently formed this structure around the time of launching share offers. One group changed their structure when they launched their share offer in order to benefit from the tax advantages. Some groups selected this structure after receiving consultancy advice paid for by Cooperatives UK whilst another group researched the different structures themselves.

Groups that had not run a share offer were less likely to be registered as an IPS. Forming unincorporated groups, community interest company (CIC) or companies limited by guarantee. One interviewee commented that they had been unable to register as a charity as they did not meet all the conditions. Some groups have remained unincorporated following successful implementation of a community energy project. However another group commented that setting up a company had helped motivate the group to carry on.

One group in the early stages of planning their community energy project spoke at length about both their current and future structure. At the time they were formed an unconstituted partnership between two community groups in the area and a few individuals. The interviewee felt that although there were tensions in the main aims between the two community groups that the structure worked well because everyone was focused on delivering the project, luck and good judgment. They felt that such a structure wouldn’t work everywhere. Once the project was delivered a new group would be formed probably as a CIC which would be responsible for the maintenance of the infrastructure and would be made up of new people. The income and the educational side would remain the responsibility of one of the existing community groups. This structure was already in place in the area for a non-energy related community project.

5.1.5 Volunteers

Community groups typically rely on volunteers to deliver projects. This was described as an ethos based on using volunteers. Delivery of a community energy project was described almost universally as a huge amount of work, like having a second job. The majority of volunteers were involved because they believe in the aims of the project. Some groups offered volunteers small rewards, such as firewood for work, however this was not always claimed.

For a project to be successful volunteers have to invest a lot of time and effort into the project. One interviewee attributed a previous lack of activity to the limited amount of time key people had invested. Volunteers with full time jobs are unusual. However those few that were involved were typically described as key to the success of the group. It was felt that a major downside to having volunteers with full time jobs was that they were less able to respond quickly (i.e. throughout the day) if anything happened. Interviewees highlighted that they had struggled to recruit more young people who they felt were busy with jobs. The majority of volunteers are retired. The sector may have benefited from cuts to the public sector: interviewees commented that a number of people involved had taken early retirement and were volunteering now because they still expected to be working. Some volunteers had given up jobs in order to devote more time to the project. However unless they had strong familial support this was unsustainable in the long term. Volunteers were typically seen as having to be incredibly committed, both in hours and emotionally. One interviewee commented that being able to volunteer depended a lot on your personal situation at the time.

Most projects were delivered by a stable team of volunteers. The main cause for drop outs was moving away from the area, however internal conflict had caused some volunteers to leave. Reasons that volunteers joined the community group were being headhunted by existing members for a particular skill or moving into an area. There was a perception that community groups were frequently comprised largely of individuals not indigenous to the area. Although it was suggested that volunteers wouldn't stay if they didn't enjoy it, volunteers may also stay because they feel trapped - if they left the project would collapse.

“you know they have devoted huge amount of effort to making sure it happens but we’ve remained, you know the group fortunately has remained true and that’s just luck, as I say we’ve lost one person because his wife wanted to retire somewhere else, so they’ve moved, but he’s still in touch, because of course with IT you can remain fairly closely in touch. So we’re all together.” – Interviewee 05A

Other projects however have had less stable teams. However they have found that the total number of volunteers has stayed constant throughout. Teams are usually small, between 4 and 25 people working on one project. The contribution from different volunteers varies and interviewees felt that the same volunteers were doing all the work. The majority of groups felt that they needed more individuals to volunteer in order to be sustainable. However one group that managed to attract an influx of new volunteers found that they were unable to find something that the volunteers had the skills to do. Finding the right person to carry out the project was felt to be important by some groups. Not all groups are keen to expand. One interviewee commented that

the group was small and worked well together and so were yet to include the individuals from the community that had contacted them to volunteer.

Following delivery of a community energy project some groups have expanded. Reasons given for this expansion included a reduction in time commitments and wanting to be part of something successful. One interviewee commented that the skills mix and interests of their volunteers had moved from engineering interest to social education following installation of the project.

Interviewees frequently referred to issues they had experienced due to volunteering. The time volunteers can commit is haphazard or limited. Administration and research was felt to be too time consuming for volunteers. Volunteers responsible for large sums of money often felt a huge amount of pressure to deliver the project successfully. Many groups use a website to promote their work. However they have found it difficult to get volunteers to update it on a regular basis unless someone is assigned to the job. Community energy projects are frequently based on or around community buildings. These buildings are often managed by volunteers. This has slowed the delivery of some projects due to the time delay in communication between the two sets of volunteers.

There appeared to be a certain amount of pride in what they had managed to achieve without paid employees. However there was a pervading feeling that paid employees increased the long term sustainability of the group and is the only way they could have a real impact. Several interviewees suggested that a paid employee would reduce the risk of volunteers becoming worn out. Some community groups already employ staff members although this is typically limited to one or two, supported by a team of volunteers. Employees may have originally been a volunteer or they may have been hired to provide a specific skill, often project management or accounting. Wages are usually a fraction of what the individual could earn and only fund part time work. The employees frequently however work full time on the project due to the volume of work. Having paid staff keeps the project moving along, i.e. by monitoring and responding to emails as they arrive. Community groups that have employees frequently also have an office, which provides meeting space and access things like photocopiers. One interviewee stressed the significance that access to office space had to their progress.

Most of the groups that had employed someone had been able to do so predominantly because they had received a grant from the local council often to undertake energy efficiency advice. However grants, especially those which would cover core funding were felt to be increasingly difficult to access. Continuing to employ someone requires a stable income. Some groups had accessed grants to provide someone with a one off payment to cover a set number of work days. Although the work frequently took longer than the allotted time, the individuals involved continued to provide help.

5.1.5.1 Skills

Many of the interviewees highlighted the complexity of a community energy project and the range of aspects that need to be addressed. Aspects vary from obtaining planning permission, creating legal agreements, understanding the life cycle of fish to understanding the electrics. This creates a

steep learning curve which community groups must overcome to deliver a successful community energy project.

Interviewees generally felt that their group had a good mix of skills and experiences within the core group that had helped them to be successful. Often the groups had started with a fairly broad range of skills, but had then approached individuals in the community with specific skills to supplement the group.

“If you can’t build up that sort of those skills it’s very hard, if you’re just a few home owners who get together in the church or something like that and want to do it, I wouldn’t like to think what it’s like. I mean you might get PV panels on the roof of your church or your local school, but dealing with OFGEM and things just start to become too much probably.” – Interviewee 08A

However they also identified that they were missing skills, typically legal or financial. Many had accessed advice from external businesses, charities or individuals to fill the skill gap. The advice had come from a range of sources, some of which had been funded through grants, some of which had been given pro bono. Obtaining pro bono work was described as being part of the game of community energy and frequently utilises the groups own social network. Networking between community groups carrying out community energy projects is another source of advice that interviewees had accessed. One interviewee expressed an interest in offering advice to other community groups.

The skills base of those involved in the projects had increased. This was mostly via skills transfer within the group or due to undertaking the activity. Knowledge of the technology installed was the most frequently cited example of upskilling.

“It’s interesting being involved being with young people who’ve got the ideas and the knowledge. You know I’ve learned things that I would never have learned otherwise.” – Interviewee 10A

Some community groups had been able to attend workshops or courses that had been put on for free to learn new skills. This had helped focus the group to carry out the project. Skills gained typically focus around delivery of one specific model and technology.

5.1.5.2 Motivation

Motivation is key to long term sustainability of community energy projects. There was concern from some interviewees that long term enthusiasm was lacking. It is often easier to motivate people at the start, but harder to keep that going. Encountering resistance to or problems with design of the project reduces morale and enthusiasm.

Most community groups do not have a stable income and consequently devote a lot of resources to writing bids for funding. These are frequently unsuccessful which can impact on motivation, leading some to suggest that funding bid writing support should be made available. The success of the projects often relied on personal energy, frequently one member who kept everyone going

when motivation was low. However one interviewee commented that they had been motivated by knowing that there were people in the community willing to stand up for the environment.

Successful delivery of a project has motivated some groups to start new projects. However some interviewees expressed doubts about being involved in subsequent projects due to the stress they had undergone. Enthusiasm seemed to wax and wane around times of success, either internally or externally recognised or provision of a new focus. One group had set up a legal structure principally to maintain motivation.

“Yeah we have done a lot of really really fantastic things and been, it’s easy to become very very negative about these things and you look back and it does buoy me up that you know.”
– Interviewee 11A

Pride in the project improves motivation. It was not uncommon for interviewees to comment that they were the first to do what they had done. Although this may have consequences for wider uptake of community energy projects, interviewees were usually adept at being able to explain how in some small way their project was novel. Additionally, whilst groups were proud of their own project, they were also proud of the achievements of other groups and often hoped to emulate them. Networking between community groups can reassure and motivate as experiences are generally the same.

5.2 Project

This section explores the factors which have affected the development and implementation of the project. It also looks at the decision making process and why certain decisions were made.

5.2.1 Timescale

The overwhelming majority of interviewees commented that community energy projects take longer than other projects and usually a lot longer than anyone thought before they started. PV projects took around one year and hydro around four years. The length of time is frustrating and can affect the motivation of volunteers. The length of time it takes to get many parties to agree to the project and to sign legal agreements was identified as the main reason for the length of the projects.

“The process of putting solar panels on the roof of the building quite complicated because essentially it was a deal between [local] Council and [community group] but on a roof of a building that is being leased by [community building management] so it was quite a complicated deal” – Interviewee 02A

Other issues that were identified include: overcoming problems, raising funds, locating a site, obtaining planning permission and external agencies changing goal posts. It was not uncommon for statutory agencies to require groups to apply for one type of permission, to later decide they didn't need to apply and vice versa. Some groups attributed this to the recent public sector cuts, which they felt had caused a loss of expertise. Other groups felt this was due to the community nature of the project causing confusion.

Hydro projects have a long lead in time. This has partially been attributed to delays gaining approval from the Environment Agency due to what was described as poor internal communication and conflicting aims. However certain aspects of hydro projects can only be carried out at certain times of the year, which can cause significant delays if deadlines are missed.

The long delays in projects have meant that some projects have missed out on more advantageous feed-in tariffs. Some projects have had to be redeveloped as the dropping rate means that some projects, mostly PV projects, are no longer considered to be viable.

Not all projects took a long time, some were relatively quick. Most groups felt that they would be able to carry out subsequent projects in a shorter timescale due to the knowledge and skills gained.

5.2.2 Funding

Although the community nature of the project means that some things can be accessed for free, community energy project require funding for a wide variety of things, for example: buying the generator, hiring rooms for community meetings, advertising, legal advice etc. Different groups have managed to gain different things for free. It was identified in Chapter 4 that most groups had accessed a range of funding.

Most groups had not carried out reports such as feasibility studies, design studies and environmental impact assessments unless they were required by statutory agencies etc. unless they had been awarded a grant that could be used to pay an external company. Additional to the usual sources of grant funding, several groups had been awarded grants by local community energy groups that were larger and more developed, that had money in the bank. These groups commented that it had helped focus them on specific projects that they would not have identified had they carried out the study or that it gave them more authority when talking to potential participants.

“Anyway we were offered some funding for [company name] which are a low carbon consultants to come and do a survey on all the community buildings and look to see where we could make improvements to them and how they could run more efficiently so that was fantastic and has been so useful hasn’t it, because now we have actually got something official from a bona fide company that can just say you should be doing this this and this, whereas before, we knew but it sounds much better from someone like that” – Interviewee 11A

Although a few groups had carried out their own feasibility studies, most interviewees felt the group did not have the required skills. The majority feeling was that share offers couldn’t be carried out to raise money for anything before installation. Although a few groups had raised capital through pioneer share offers (high risk shares as the money cannot be returned to the shareholders unless the project goes ahead), not all had raised as much as required. Therefore it was widely felt that grants were required to carry out such studies and that such studies would be beneficial.

“if they could help towards feasibility studies because that’s obviously a bit of a risk capital in the sense that it’s costs that you have to put up with before you know whether the project can even go ahead and it’s very difficult to issue shares for risk capital. So that might also be a way the government could assist communities.” – Interviewee 09A

Capital to install the generator was raised through: grants, share offers and loans. Groups had commonly raised money using a variety of methods. A few groups had taken out bank loans to cover up to half of the costs. These loans were generally organised prior to issuing a share offer. A likely explanation is that these groups do not feel it is possible to raise that much money through a share offer alone. One interviewee was concerned their project may not go ahead as the capital costs were felt to be too high. However several groups found that they had raised more than they had aimed for, with one interviewee postulating that it is easier to raise large amounts of money than small amounts. There were different approaches for dealing with the excess: paying some back to everyone so that everyone could invest and using the excess to do additional projects. Excluding individuals in the community from investing in share offers by setting a minimum investment was a concern for some interviewees. Administration for each shareholder takes the same amount of time each year, regardless of how many shares they hold. It would result in a lot of work to have a large number of shareholders each with a small number of shares. Therefore many community groups have instigated a limit on the minimum investment they will accept. This limit is frequently either £250 or £500. These numbers appear to be used on the basis that other groups have previously used them, one interviewee thought that it was a minimum set by law. It has been

argued that this limit is a barrier to participation. One group who were particularly concerned about this allowed people to invest small amounts over a 10 month period. They also allow volunteers with a certain number of hours to become voting members for £1. Another group paid back shareholders that had invested a lot to ensure that everyone in the area that wanted a share could buy one. Only one group had limited the maximum investment to £1000 (IPS law limits it to £20,000). This was done to ensure that they had a large number of investors, rather than other groups who had been funded by a few large investors. One interviewee commented on plans to increase the maximum share investment that they had never had anyone trying to invest that much, but it would be good if they got a large firm involved. Investors were typically local to the area which was a source of pride for the groups. However investors had withdrawn money from one scheme when the technology was changed, so that they could invest it in a scheme using the original technology which was not local. This suggests that not all investors are interested in the community nature of the project.

Although a few groups had received grants (full or partial) only one had received a grant from a traditional source post the 2010 introduction of feed-in tariffs. The directors of this group were considering paying back some of the grant as using it meant they were not eligible to receive the feed-in tariff payments. Several groups had effectively received grants for the technology from either another community group or a local business. In the case of grants from other community groups however the group did not then receive the feed-in tariff payments and appeared to show a lack of responsibility for the technology. One group had received a grant from a competition. However this competition has not been repeated.

“Share issue and bank loan, yeah. We would like some grant money, but I don’t think that’s going to happen.” – Interviewee 13A

Although use of grants for generation installations is falling, this is typically not due to a fall in desire for them. Groups are devoting a lot of volunteer time to applying for grants. Within groups with a fairly stable income there is some difference in opinion about applying for grants.

“Possibly, possibly although I always feel slightly guilty about applying for funding because most communities don’t have an income, we do have an income.” – Interviewee 12A

“We are quite privileged. We have had money in the past from a [funding organisation] when we were starting up the [project] and things but there is nothing that says we won’t do that. If we got to a certain point and there was just one more bit we needed I could see us perhaps applying for some other funding” – Interviewee 12B

Interviewees identified three factors that they felt had led to a fall in grant use. They felt there had been drop in the amount of grants available due to the financial crisis. State aid cannot be used for the generation technology if the group wishes to be eligible for the feed-in tariff. Funders are unwilling to provide capital for something that will make money for the group. One interviewee felt that it would not be possible to access grant funding for projects unless an agency or body funding pilots was created.

Interviewees often commented on the additional costs of projects: running public events, funding project managers and advertising. These costs were typically covered by large grant funding prior to the project being installed and receipt of the feed-in tariff. Only one group had used traditional community method of raising small amounts of capital to cover these costs by hosting a bring and buy sale and selling Christmas cards.

5.2.3 Sites

Community groups typically do not own physical resources such as buildings or land. It was extremely uncommon for any groups to think about buying a building or land to gain access to a site. All groups had to negotiate a contract with the site owners. Some groups had been able to negotiate very low rents, such as peppercorn rents or free in exchange for free electricity, because of the community nature of the activity. Other groups however had faced a long process of negotiation where the cost of the site was pushed upwards. This can be a particular problem for community groups based around a physical location as the number of sites is limited, potentially to the point where a site owner could have a monopoly. Sites were identified as being limited by tensions over land use, i.e. national parks and by planning officers. Site owners however, had generally responded positively to the local nature of the projects and preferred community groups over non local commercial projects. This was linked by several interviewees to the fact they were neighbours and so would be able to contact them if there was a problem.

Community buildings are frequently picked by community groups as sites.

“So that’s why a lot of community energy groups end up with community halls covered with PV, and we’re the same, so our community hall has got all singing all dancing this that, because it’s one thing you can actually spend the money on that belongs to the community”.

– Interviewee 12A

However not all community buildings are ideal for PV, the following were identified as issues encountered by the groups: they don’t face the right way to maximise the generation, the roof may not be strong enough and the electrical infrastructure may not be up to scratch. Community buildings are usually owned by the council and leased or managed by a management committee (another community orientated group). Therefore negotiations and contracts are trickier than a building owned by the user, as it becomes a three way agreement. This position may change over time if more communities use the Community Asset Transfer³ to take over ownership of community buildings from councils. Churches and schools also have similar problems when negotiating contracts. Several projects were delayed or downsized due to issues with negotiating contracts.

Local companies or individuals that owned their own building did not have the same problems. However some groups had found that owners of these sites were unwilling to lease the site for community energy projects as they eventually wanted to be able to do it themselves.

³ Community Asset Transfer is a process where local councils gives management responsibility to an organisation such as a community group, of a building owned by the council that is used by the community. The aim is to reduce the need for council funds to maintain these buildings.

“They reviewed all the various potentials for community energy and they looked at wind but of course you need land, you need land that’s owned by the community to do it because of the land owners if they’ve got the chance to put up their own turbines and take their own income, so wind was ruled out and then even though it provides more energy because we hadn’t got a site.” – Interviewee 05A

5.2.4 Selecting generation technology

Groups have focused predominantly on consideration of technologies that generate electricity although some have additionally considered heat generation. The principal technologies mentioned are photovoltaic (PV) systems, wind turbines and hydro power. Interviewees identified a range of reasons for why various technologies had been considered and why others had not been, these are summarised in Table 5-1. This table is discussed in detail in the following sections.

5.2.4.1 Hydro

Reasons considered for carrying out Hydro projects are significantly different to those given for other technologies. The principal reasons given were: an interest in the engineering behind the technology, the historical significance of hydro power in the area and encouraging tourism to the area. Unlike other technologies, none of the reasons were based directly on economic considerations. This may explain why only hydro schemes were considered by the sample prior to the introduction of the feed-in tariff. Groups both pre and post the introduction of the feed-in tariff had or planned to obtain grants due to the high costs involved.

Several groups had considered hydro because they knew of other groups that had successfully managed a hydro project. Knowledge that something is possible can encourage others to do the same. Rivers were considered to be a community resource and therefore particularly poignant for a community energy projects. Groups involved with hydro power were motivated to do so as they felt that it would bring tourists to the area as it is currently seen as unusual. This may change over time as hydro projects become more common.

Hydro was perceived by many interviewees as a controversial technology due to the experiences of early hydro community energy projects. Some interviewees had spoken to some of these groups to research what would be required. They reported that these projects had struggled to work with the Environment Agency. This was partially due to the high number of individuals they had to contact to gain approval for the different aspects of the projects. Additionally these groups had faced campaigns from what interviewees reported as a national anti-hydro lobby, consisting mainly of anglers and river ecologists.

Interviewees were concerned about the high upfront costs that would be needed to cover things like feasibility studies, environmental impact assessments etc. as well as the high costs of building the infrastructure and buying the turbine. There were also concerns around the length of the process. Some groups did not consider hydro because they didn’t have any sites in the area, mostly caused by a lack of energy resource at nearby weirs. The majority commented that this was a shame.

TABLE 5-1 REASONS FOR CONSIDERING OR REJECTING TECHNOLOGY

Technology	Positive	Negative
Hydro	<ul style="list-style-type: none"> • Engineering interest • Existing model • Community resource • Historical significance • Tourism 	<ul style="list-style-type: none"> • Controversial • Environment Agency • High upfront cost • Long process • No sites
PV	<ul style="list-style-type: none"> • Easy • Competition • Generation profile • Good sites • High investment return • Low maintenance • Low upfront cost • Predictable • Short process • Uncontroversial 	<ul style="list-style-type: none"> • Low investment return • New
Wind	<ul style="list-style-type: none"> • Good sites • High investment return • Stable income 	<ul style="list-style-type: none"> • Controversial • Diversity of generation • High maintenance • Governance anti-wind • High risk • High upfront cost • Long process • No sites
Small wind	<ul style="list-style-type: none"> • Grid connection • Low maintenance 	<ul style="list-style-type: none"> • Efficiency
Air Source Heat Pump (ASHP)	<ul style="list-style-type: none"> • Existing model 	<ul style="list-style-type: none"> • No sites
Biomass	<ul style="list-style-type: none"> • Off gas-grid 	<ul style="list-style-type: none"> • Complex
CHP	<ul style="list-style-type: none"> • Good sites 	<ul style="list-style-type: none"> • RHI complex
CHP (district heating)		<ul style="list-style-type: none"> • Financially unviable
CHP (individual site)	<ul style="list-style-type: none"> • Financially viable 	<ul style="list-style-type: none"> •
Solar thermal	<ul style="list-style-type: none"> • Financially viable • Grant 	<ul style="list-style-type: none"> • Inflexible carrier • RHI complex

5.2.4.2 Photovoltaic systems

The majority of groups that installed PV or were thinking of doing so linked their choice principally to the introduction of the feed-in tariff scheme which in their opinion made it financially viable.

“some people have said to us why didn’t we go for ... solar from the beginning... solar was quite new and there wasn’t a feed-in tariff for it.”- Interviewee 10A

There appears to be a strong correlation between PV systems and the feed-in tariff. The reduction in rates announced in October 2011 affected the plans of the majority of groups planning to install PV systems. However only a minority of groups abandoned planned PV projects and this decision had been made in the immediate aftermath of the changes. These groups now planned to look at other technologies. Most groups still planned to carry out PV projects but were having to develop alternative financial models or were waiting for the cost of panels to fall.

There were a number of secondary considerations mentioned during the interviews. Energy generation was felt to be predictable and therefore would provide a steady, predictable income for the community group. It is quick and easy to install on roofs as well as maintain. Good sites are available in both urban and rural areas. Upfront costs are low as expensive specialist reports are not required for the project. Interviewees consider upfront costs difficult for community groups to deal with. It is seen as an uncontroversial technology.

A minority of groups had encountered some level of scepticism. However this wasn’t interpreted as resistance and didn’t cause any delays. Scepticism came from two groups: those overlooking the projects, who were concerned about the visual impact and elderly members of the community. Interviewees felt that elderly members of the community were sceptical because they may not see the returns. One group had installed PV because it was what they had been offered through a competition. There was some consideration of selecting technology based on matching generation profile to the demand profile of specific sites. This however, was an atypical consideration.

5.2.4.3 Wind turbines

Although many of the interviewees viewed wind positively, it typically was not seriously considered by community groups principally due to their perception that wind turbines are a controversial subject in the UK. The majority of reasons for not considering a wind project were similar to those considered for hydro projects. It was widely felt that the Government and some local councils were anti wind and therefore would be unwilling to support community groups to install wind turbines. Many felt that although it was achievable, it would be more sensible to avoid the issue. Objections would extend what was already perceived as a long process due to the requirement to provide environmental impact statements etc. They would also risk losing the motivation of volunteers.

“Anyway it got put up but it does bring home to us the difficulties of doing it and if we are funding systems with community finance we have the difficulty in that you have to put up a great deal of money beforehand especially if people tend to fight and you have to pay legal fees and such like and there is always a possibility that it won’t go ahead and you have to find some very understanding investors who will put their money in on a fair chance that a lot of it be spent and they won’t get it back” – Interviewee 08B

The availability of sites was given as a reason for considering wind, whilst a lack of sites was given as a reason for not considering wind. It was clear that all groups had a good idea that a site was more than just a patch of land the correct size. The energy resource in the area was frequently identified as an issue: some groups had access to some evidence of the wind resource whilst some spoke more generically about the area being windy. Lack of land ownership was an issue that was felt to be a particular problem for community groups. A minority of groups drew attention to other issues affecting sites due to their locale, such as being based in a green belt or close to an airport. The availability of good sites isn’t closely linked to the rural or urban nature of the groups. Some saw the lack of sites as a good thing as it allowed them to avoid confronting the issue. One group commented that by avoiding wind projects they were improving the energy diversity in the region as there were many commercial wind farms in the area.

Providing ongoing maintenance was seen as an issue, with reference made to concern about moving parts. This was compared with the low skilled maintenance required for PV.

Groups that had seriously considered wind identified them as providing the highest generation for the least investment. The high generation is linked to the provision of a stable income.

There was limited distinction between large and small scale wind turbines by interviewees, it is not clear therefore if these issues are specific or not to any particular scale. However a small proportion of interviewees mentioned issues specific to small scale wind. There is no gear box and therefore maintenance is easier. Infrastructure costs can be lower if existing household power supplies can be used. However this is less applicable in rural locations where the electrical grid is more likely to need some level of reinforcement. Small wind is not so efficient at producing electricity especially if it is located close to housing.

5.2.4.4 Heat technology

A minority of community groups appeared to have considered using low carbon technology to generate heat. Technologies considered include combined heat and power (CHP), solar thermal, air source heat pumps (ASHP) and biomass.

ASHP were considered in one case because another group nearby were doing it. However the group quickly realised that the houses in their area were not suitable for ASHP as they are mostly old with little insulation.

Biomass appears to be constrained to rural areas with woodlands. It has predominantly occurred because areas are not connected to the gas-grid, where heating is a particular issue. However production of biomass requires a supply chain to be set up, which some groups saw as complex.

CHP both for individual sites and for district heating was considered. Groups had identified a number of good potential sites. However the renewable heat incentive (RHI) – the heat equivalent of the feed-in tariff was felt to be too complicated and groups weren't sure how they would be able to use the incentive. Although CHP as an individual site was felt to be financially viable, that at a district heating level was not.

Solar thermal had been considered because it was felt to be financially viable to install it. One group received a grant. The complexity of the RHI was mentioned as a reason for not considering solar thermal seriously. One group felt that generating electricity rather than heat would be more suitable as it could be used to power more features of a building.

5.2.5 Manufacturer

The most common reaction to a question about the make of PV installed was to discuss the country in which they were manufactured. Indicating that country of origin was a higher priority for groups than the brand.

Most groups had followed the advice of their installer. Interviewees commented that the installers had told them the panels they recommended were the best. There was no definition of what best entailed, however reliability appears to have been a concern for some groups. There was a small amount of concern about Chinese PV panels being mass produced and flooding the market.

Research of the different products available was felt to be time consuming by several interviewees. They had been aided either by external help or by the microgeneration certification scheme (MCS). The MCS was considered beneficial as it limits the number of products that the volunteers have to compare. However this research is required each time as new models are created.

5.2.6 Installer

It was important to some groups that the installer was local to the area. Some went further and wanted the installer to provide some skills training to individuals if they were working in a deprived area. Other groups preferred to use companies that were well established and provided guarantees of their work.

5.2.7 Installed capacity

Many of the projects developed following the announcement of the feed-in tariff were designed to be the maximum size for the feed-in tariff band into which the group thought they would be able to achieve. Only one interviewee indicated that the size had been chosen to maximise the returns from the feed-in tariff. Other interviewees denied that the size had been chosen based on the feed-in tariffs when asked directly. However they usually then went on to indicate that generator was the largest size they could have to qualify for the feed-in tariff band. The feed-in tariff bands means that frequently smaller installations are installed where larger ones are possible. Several interviewees, all of whom were engineers, were unhappy about the banding structure as they felt it was not based on an understanding of the energy system.

“The max you’re allowed to install is 4kW and that’s from the government side, but from the generators side because nobody knows their arse from the bloody elbow, because there aren’t enough engineers in politics, you get a situation where if you want to generate over 16 amps in the UK you have to have authority from the grid effectively and so if you go over 16 amps which is 3.6kW you end up having to go through a fairly long protracted affair. So although we really wanted 4kW on everything, we ended up with 3.6 just for expedience to get the bloody things up.” – Interviewee 11A

Only one group implied that they had ignored the feed-in tariff bands when designing their project. They intended to match supply to demand. The interviewee felt that the feed-in tariff rate was not enough to warrant designing the project around it. This feeling may stem from the group’s earlier projects falling through due to the main changes in the feed-in tariff.

Other factors which had affected the size of some projects were: money, obtaining planning permission, roof size and the visual appeal of the system. In this last case the installed capacity was decreased in order to be able to fit the PV system into a neat rectangle.

One interviewee commented that installations above 50kW were difficult for community groups to manage as the process is more complex for a smaller rate of return than for smaller projects. However rather than causing the group to only consider smaller projects in the future, they were considering one very large project. This was because they felt that the paperwork to manage one big project would be easier than paperwork for many projects. They did however raise concerns that they would have to be involved in the contract for difference electricity trading scheme, which they felt only the Big 6 would be able to cope with. They also raised concerns about big projects being limited by connection costs to the electrical grid.

5.2.8 Maintenance

Interviewees often referred to guarantees or insurance on the technology when asked about maintenance. Maintenance is dependent on the type of technology. Building mounted PV is generally thought not to need any maintenance. There is some difference in opinion on whether or not PV should be cleaned occasionally. Large scale PV, Wind and hydro systems require both annual checks (high skill) and regular maintenance or checking (low skill). A minority of groups, all in the pre-delivery stage thought that some low wage, part time maintenance work would be created. However most groups paid or planned to pay maintenance companies to carry out annual checks, whilst volunteers carried out daily checks.

5.2.9 End of life

Little thought had been given to what would happen to the technology at the end of its life by groups at all stages of development. Uncertainty over what would change during the life time of the technology was cited by some interviewees as a reason for not considering end of life scenarios. However others felt that it should be discussed during planning, although they highlighted that the issue was likely to lose out to more immediate issues that must be dealt with at that stage.

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Groups that had been required to provide a winding up scenario had considered end of life scenarios. Winding up scenarios are required by the Environment Agency for hydro schemes and by the lease agreements entered into by some groups with owners of land or buildings. However these scenarios are designed to ensure that the community group secures the requisite finance to be able to remove the technology from the site when requested to by the site owners. They do not encourage the community groups to consider what they will physically do with the technology once it is removed from the site.

After prompting to consider the issue, only a minority of interviewees considered what they could physically do with the technology, commenting that if it was still functional it could be sold, or that some parts could be recycled. Instead many focused on what technology would be available in the future to replace it, including energy storage. It was felt that technology would have significantly improved within the next 25 years but that the feed-in tariff scheme would no longer be in place.

Many of the interviewees seem to display a lack of responsibility for the technology, commenting that the life time is likely to be longer than their own so it doesn't concern them or that they expect the site owner to take over responsibility. However these same people indicate that they are concerned about climate change because of the effect it will have on their grandchildren.

5.3 Income

There is a disparity in the importance placed on an income stream which may partially stem from the age of the group (pre or post feed-in tariff). Groups that had started hydro projects prior to the feed-in tariffs commented that they thought they would be viable because they would be able to sell the electricity. This appears to be limited to being able to pay for maintenance rather than creating an income stream.

“I don’t think there was a feed in tariff for [project] when it started, but we always thought we would manage just by selling the electricity. And the feed-in tariff for solar has changed, has gone down a lot over the last year, two years. But then the costs of solar panels has come down so it’s, I mean people who are in, into solar PV just for making money have been very annoyed about that. But although we need an income you know, we’re not in it just for the money” – Interviewee 10A

“So I’m involved with [local] council trying to get other communities doing similar projects because it is an easy way to some extent to raise funds for local communities if they have a good wind spot, but CO2 emissions is not usually high on the agenda, if you ask people what changes would you like to see in your community it’s usually a lot of other things that they list, but if you then ask them well how do you intend to fund those changes, then you can sometimes suggest well you could generate some electricity for instance and raise some funds that way to pay for the things you want to do in your community.” – Interviewee 09A

Some groups, typically those that had not raised the capital for the projects either did not know where the feed-in tariff payments went or knew that another group received it but did not know what they did with it. These groups did not seem to mind not receiving an income stream, although one interviewee did comment that this was because they felt it a fair deal on the basis it was not much money.

The remaining groups used some of the income to cover overheads such as insurance and maintenance. The proportion of income is dependent on the type of generator. Groups that raised share offers or loans use the feed-in tariff to pay these off. The rate of return offered to shareholders is typically between 3% and 7%.

“You know, we think maybe 5 or 6% would be enough to attract people, at the moment you are only getting 2 or 3 if you are lucky at the moment or less than that typically, half a per cent or a per cent so why not go for 5% you know, in fact which would give us a, a quicker pay back and more community benefit coming out of it you know we are paying less out in interest in shareholders to do that so I mean we wouldn’t be doing it if we weren’t that confident” – Interviewee 07A

The risk to investors and to the community group is generally considered to be low. The source of income is from a government scheme which provides a fixed rate for a long period of time. However the groups are dependent on this one source of income. The income from the export rate was generally dismissed as minimal; although the export was lower than expected in one project, it had

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not had a major impact. Several interviewees highlighted that paying back investors reduced the finance they could initially put towards other things, although this would lessen as loans and shares were paid off. One group planned to raise more capital than required for the project in order to create an initial community benefit fund.

“we’re planning to do is actually build an amount of sort of initial community benefit payment into the initial capital so that if it’s a 40,000 pound project we will add 5000 pounds on so it becomes a 45,000 pound project and then you raise 45,000 pounds through a share issue but 5000 pounds go into a community benefit pot to be distributed in some way or other which we haven’t quite worked out and obviously over the life time of the project once the shares are paid off and that kind of thing there is a significant surplus, it tends to come quite near the end and that’s the trouble with it and that’s why we want to put some upfront community benefit into it by putting it onto the initial share offer, it seems like the right way to do it. Then at least people can see an immediate benefit of doing it as well as community ownership and other things and savings to whoever the customer is.” – Interviewee 07A

Most community groups planned some sort of community benefit fund. However the organisation and purpose of these funds differed. The majority of funds allow members of the community make proposals of how the money should be spent. One interviewee hoped this would produce some inventive uses of the fund. However groups already asking for proposals from the community had not received many that were considered suitable. In most cases the decision of which proposals to fund is made by the community group. At least one group have tried creating an independent board to vote on which proposals to fund, after carrying out an initial filtering against the criteria of the fund. However this is reversed by some groups, with the groups proposing projects, which are voted on by the shareholders. Some funds are run annually, whilst others are not run so regularly. The majority of funds could be used for anything considered sustainable, such as setting up sustainable businesses or supporting production of local food. A minority however were specifically for investing in energy projects, both generation and efficiency. Some funds were open to households, businesses or community groups in the community. Others however were (or would be) only open to community groups to apply. One group planned to use the money to gain match funding, which they felt would only be available for work on community buildings. However for some groups funding only projects that would benefit the whole community at once was seen as the only fair method of distribution.

The advent of resource streams (energy as well as monetary) into the community brings with it the issue of distribution. The feeling of many interviewees was that the distribution should be fair, with most appearing to base concept of fair distribution on the notion of equality.

“It’s actually harder than you think to spend money on a community. Let alone a community sustainable project. So we don’t spend money in a way that benefits any individual, business or household because that would be, we don’t, as [Interviewee 12B] said we don’t have enough that we can benefit everybody so it would be very awkward if we actually benefited this café over one of the, we have four pubs, or cafes and things or one household over another” – Interviewee 12A

An equity distribution may be difficult for community groups to achieve. One group had been met with suspicion from the community when they attempted to provide an equity project on behalf of the local council.

“In the beginning they weren’t sure what they were going to do but it doesn’t generate enough to give electricity to all the village so how do you decide who gets it and who doesn’t.” – Interviewee 12B

Some groups planned to reinvest at least a portion of the income into additional generation projects. Several groups had donated the feed-in tariff to the community building management committee for a fixed period of time to allow them to fix the infrastructure of the building. A minority of groups however felt that providing free or subsidised electricity to the building was enough. Job creation is frequently quoted as a wider benefit of the community energy sector as well as a requirement for its long term stability and growth. However only a minority of groups used or planned to use the income to create direct employment. These jobs are often part time work for minimal wages. One group were uncertain what would happen to the income after the shares were paid off. This group was not formally constituted which may have caused the uncertainty in its long term survival.

5.4 Community engagement

Community engagement was considered to be important to the majority of interviewees although one interviewee felt this sentiment was not applicable to the whole sector. Interviewees felt that community engagement was important to encourage households to take action, to reduce resistance to the project, to gauge support and to focus action where desired. There was some concern about the impact of announcing a project too early in its development. Some felt that it may give time for an anti-campaign to establish, before the group were ready to defend the project.

The level of community engagement typically fluctuated over time. Interest from the community often fell over time during development of the project likely due to a loss of motivation. Once the technology was installed, some groups had seen a rise in interest. There may be two aspects to this change: the phrase “seeing is believing” was used in a number of interviews and some had hosted events to coincide with commissioning or were planning to focus on engaging households following commissioning. One interviewee felt that the group had lost popularity because of how the income was spent. Another group felt they struggled to engage with the community as they were seen as outsiders by some elements of the community.

Community engagement is a fairly vague term and most interviewees identified a number of different levels of engagement. Some interviewees considered awareness of the project and the group’s activities to be a sign of engagement, where others did not. One group had three clearly defined levels of engagement in order to include individuals with different circumstances.

“We wanted to engage or involve the whole community. And we use the word involve, it’s very important to us is that engage has got this kind of terminology about it which doesn’t really sit easy, with people when they just want to do something, it feels bureaucratic. So we decided to scrap that as a word and use involve. And what we’ve tried to do is involve as many people as we possibly can within our community and get them to become inspired and put in measures within their own homes.” – Interviewee 06A

It was frequently noted that it was the “same old faces” who engaged with the projects, typically those concerned about the environment. However not everyone who was interested in the environment was also interested in energy. Most groups had tried to engage those that weren’t usually involved with environmental issues with mixed success. Several attempted to use existing community networks, such as schools and village halls. The vast majority have tried to engage the community by promoting the personal financial benefits of the projects, rather than the environmental benefits. Households not connected to the gas grid were often more eager to participate. This was attributed to rising energy prices impacting these households first. Interviewees typically hoped that being engaged with the project would encourage households to think about their energy use.

“We were pushing the green agenda and really at this point we were just making no new progress and it’s the same people and all the rest of it and you’re not, we weren’t engaging with the rest of the community so I had this brilliant idea to go for the wallet and yeah we got a different tranche of people that we could then green wash” – Interviewee 11A

Almost universally, groups had used public meetings to try and engage the wider community. The success of the public meetings was typically judged by interviewees by how many people had attended, with particular reference to people not already involved. These meetings had achieved different levels of success. The meetings that had more success typically involved free catering. Areas where there had not been high attendance attributed this either to apathy or simply that people weren't that concerned.

"We held a public meeting about the [project] ... and the few people who turned up, who lived overlooking it, were worried about the noise, ... which was fine so we talked to them ... then one chap turned up who seemed to be leading this campaign about the ecology and he wasn't local." – Interviewee 10A

Some groups had either run independent events or had a stall at the local fete or festival, with a range of activities to pull in people. Although these were viewed as successful at engaging people, they typically did not lead to new ideas or focuses for the groups.

Other methods of engagement were: leafleting and advertising through notice boards, local newspapers or magazines, running a website and regular emails to mailing lists. These were mostly to increase awareness of the group's activities, although some interviewees highlighted that it improved the visibility of the group and increased their credibility.

5.4.1 Behaviour change

"Well it's all about, as I say raising awareness it's not just, I mean the installations we've done are tiny really, they're not going to save the planet, they aren't going to make a big impact, but it's getting the message out there and also all the other stuff you know behaviour change is sort of the biggest thing really and hopefully you know, people are thinking a little bit more, the people who have been involved in things" – Interviewee 03A

Many groups are interested in reducing energy demand in the area. However there are different opinions about how this can be achieved. Groups have taken a range of approaches. A minority feel that visibility, either of the project, the technology or the energy it generates, will lead to behaviour change.

"So that's why renewable energy is for me is the way forward because they are not just, they are looking at ways of using the environment to create your energy in a clean sustainable way but also sending out the message for as long as we possibly can that we cannot sustain the level of energy that we're using." – Interviewee 06A

Some interviewees cited examples of both households and community buildings that had installed the same technology that had been discussed or implemented by the community energy project. Others felt it had no influence in the local area.

“Because we believe and I think quite rightly that however much the government invests in this, it is never going to work if people don’t buy into it and if they can take control of their small area. I mean the great British public and their homes is something else, then I think it’s going to make things happen a lot more quickly” – Interviewee 06A

Most feel that some additional action must be taken, that just because households are supportive doesn’t mean they will change their behaviour. Some have focused on education and link energy knowledge to behaviour change. Groups have worked with a range of sub-communities, working with schools and those living in areas with high fuel poverty. Language was noted as a barrier to one attempt to improve energy knowledge.

“I’m a great believer in behaviour driving attitude rather than the other way round. So if you can just get people behaving differently for some other reason, it’s fun, you know the [little electric cars] are just fun, people drive them because they’re fun and then they’re driving electric vehicle and learning about the energy and things so it’s better that way round than saying to people hey you should use this because its electric.” – Interviewee 12A

Some groups had run projects to install insulation. Most groups had limited success, even with free insulation. They attributed this to household’s suspicion of insulation due to tales of damp houses and the disruption caused. Many of the interviewees felt they lived in an area with a high proportion of hard to treat housing.

Many of those interviewed felt that behaviour would only change once the economic situation had changed and energy was no longer so affordable.

5.4.2 Support and resistance

Most groups felt that the bulk of the community were supportive of the project and received positive feedback when out talking to individuals. Some attributed this support to a lack of controversy surrounding PV, whilst others felt it was due to the ideals of the project.

“I think most people, could see the sense of it, although it’s surprising that even though what we were doing was for, well, forget about climate change and all those issues which of course we feel very passionately about, but even if you discount that our argument was what we were doing was for community benefit because, any income would go into helping people save energy, save bills but some people will still look at it on a straight commercial basis and I think its, I don’t know, I think it’s quite difficult for people when they feel they’re responsible for looking after a place to do something which isn’t necessarily directly benefiting themselves but it’s for the wider good, I think that’s still quite a difficult concept for some people.” – Interviewee 03A

A few interviewees also detailed companies and organisations that they felt had supported them.

Most interviewees distinguished between local and national (even international) resistance. This included identifying whether or not individuals were truly local. National resistance appeared to be dismissed as unimportant, but more likely to have an impact on delivering the project.

The majority of interviewees stated that they hadn't faced any major local resistance, stating that they had instead been met with initial scepticism or misunderstanding. A few communities were disappointed when they realised that the electricity would be sold to the grid rather than provided free to residents. Issues in these communities may not have been seen as resistance because they had not led to confrontations and the majority of issues had been overcome. Addressing issues raised was mostly done through explaining the projects at public meetings. One group hired independent facilitators to ensure that any concerns raised were probably addressed rather than being dismissed.

The visibility of the technology was frequently discussed in the context of resistance. There was a pervading feeling that resistance was low because either the technology was discreet or that the building was already unattractive.

A minority of groups felt they had faced major resistance from the local community. In some cases this was from a few individuals, who were very vocal, in others a whole subsection of the community were resistive. These groups discussed the need to maintain motivation and keep fighting the resistance.

The majority of groups that have looked into hydro power have encountered resistance from fishermen. Whilst most have found that the local fishermen don't want to appear supportive of the project, they are not overtly resistive of the project either. Instead the resistance appears to be orchestrated by national organisations. These organisations are well funded and have access to specialists, which gives them an aura of authority. Many interviewees had been shown the same picture of minced fish. This picture has been made available nationally, however when one group pressed the distributor on the origin of the picture they did not receive an answer. In the section of selecting generation, controversy was given as a reason for not choosing hydro.

Wind systems were also not selected due to perceived controversy.

"maybe eventually overcome the resistance to wind energy that's sort of inherent, I don't think it's really there but it's inherently being encouraged by quite a powerful anti-lobby so once we build up that sort of credibility from doing some of these smaller projects" – Interviewee 07A

However several groups that had seriously considered wind had been surprised at the low levels of objections and high support they received from the community which they felt was due to either trust in them or apathy from the community.

Several groups drew reference to the level of resistance that future projects would encounter due to existing projects. If projects had faced problems some groups felt it more likely that future projects would meet a lot of local resistance. Others used examples of existing projects that hadn't affected the community to prevent any resistance.

5.5 External bodies

Interviewees referred to a number of external organisations that they felt had influenced the development of their project and the sector as a whole. These organisations were: the British Government, the Environment Agency and various types of councils including those at local and county level. The Government has influenced the sector through policy, particularly it appears through the feed-in tariff. This policy is also discussed in this section.

5.5.1 Government

“And I think when we started we probably didn’t think we had to have anything to do with government policy or anything like that we could just do it, but then you learn that actually it’s got a lot to do with where they want to put their money, or the tax payers money” – Interviewee 08A

The majority had mixed feelings about government support but were keen to avoid sounding too negative about the government. Government policy was described positively as: okay, providing priority for renewable energy, and good revenue funding. The feed-in tariff scheme provided the potential for small schemes to be feasible through revenue funding.

Government policy was also described as: too slow, not enough action, changeable and lacking provision of capital funding. One interviewee expressed the view that the government should do more to encourage a renewable manufacturing industry in the UK. Several interviewees were concerned about the electricity bidding reform which they fear will be too complicated for community groups to use.

“It’s been fairly tight financially all the way along. If we can get a megawatt system up and going we might have enough money to have reasonably stable income for a reasonably projectable time, but yes it has, government policy has meant that we are on a shoestring most of the time.” – Interviewee 08B

Government language was described by several groups as an issue, creating negative publicity and mixed messages. Interviewees felt that both a clear and a positive message would help the sector.

“I do worry because we are so heavily reliant on political discourse and it is a discourse because, and people’s perceptions and ideas and behaviour is taken from that discourse and at the moment energy is nowhere to be seen” – Interviewee 06A

Interviewees expressed the viewpoint that the Government didn’t know what to do with the community energy sector. Although the government had seemed positive about community energy responses to a consultation about the feed-in tariff, very little had been done. There were some small concessions, allowing aggregation and removing the requirement to have an EPC for community buildings. A special tariff had not been created however. Groups were not sure how the renewable heat incentive (RHI) could be used at a community level and one was not sure if OFGEM was equipped to cope with the RHI.

5.5.1.1 Feed-in tariff

The feed-in tariff was thought by a minority to be promoting good energy demand practice by either: encouraging households to use less energy or encouraging projects to match supply to local demand.

However the feed-in tariff scheme includes an assumption that 50% of electricity will be exported by small PV systems. Groups, typically those who were closely involved with community buildings, speculated on attempting to use as much energy as possible from the PV systems to maximise financial return, rather than attempting to reduce their energy demand. The size of the installation was generally matched to feed-in tariff bands rather than demand.

The majority of groups had been affected negatively by the changes to the feed-in tariff introduced throughout 2011 and 2012. There appear to have been three main effects: community groups were put under a lot of pressure to install before the changes, credibility of community groups fell and projects were delayed or stopped.

“We had to go back to them and say look we can’t do it you know, of course that didn’t do our credibility any good and so where we had a growing relationship with a lot of people that kind of collapsed a bit so we had to rebuild from that. I think that was probably the main problem” – Interviewee 07A

Some projects, typically those early in development, were delayed as the financial model had to be redeveloped as it was no longer feasible. Although one project went ahead as the group did not spot the affect the condition changes would have on the feasibility of the project. Projects that were close to installation were hurried in order to complete before the change deadline. These projects were often affected by last minute changes such as downsizing.

“Once the government had started to, once the rumours were circulating and stuff and panels just became impossible then we were installing anything. We had panels being driven up from Spain in the back of vans and all kinds of things going on to try and keep the panels moving. So there were some Chinese, quality Chinese panels towards the end.” – Interviewee 11A

After the changes came in some groups stopped installing PV projects. One interviewee felt they had missed the boat, whilst another felt that in future only larger community groups, with more funding, would be able to undertake such projects. However other groups were undeterred by the changes and were planning more projects. One interviewee highlighted that the scheme was supposed to be a pump primer rather than long term support.

Hydro projects were largely unaffected by the changes to the feed-in tariff. Changes to other technologies did not appear to cause concern to those developing hydro projects.

5.5.2 Environment Agency

The Environment Agency is overwhelmingly seen as a barrier to hydro projects. One interviewee felt that the Environment Agency had put up a number of barriers because they didn't understand what a community interest company was. Another group had faced problems in getting potential sites tested due to a lack of resources at the Environment Agency. Most groups had approached the Environment Agency early in development to establish a strong relationship with the organisation. However relationships were described by one interviewee as superficial. Most projects had been affected by the Environment Agency changing their minds. One group had been initially encouraged but had then been told it wouldn't be approved at a preapproval stage. Another group had been asked to make a number of minor changes over time, for which they had to have new plans drawn up. A third group had been asked at a late stage to add a second fish pass. The Environment Agency was described as being supportive of projects that incorporate fish passes and accept that weirs are a barrier to fish. However in this case it appears to have backfired as the project hasn't gone ahead due to the cost added by the second fish pass.

"Well I think something like the Environment Agency, so that we could be clear from the beginning what their priorities are, you know if we had known from the beginning that their priority for the River [name] was fish and they weren't going to look very kindly on hydro power schemes that they were going to be you know, they were going to say that fish passes were the major thing then we mightn't have gone down that road in the first place." – Interviewee 10A

The Environment Agency was commonly described as having dichotomous, conflicting aims: promoting renewable energy and protecting river ecology. One interviewee commented it was likely that flooding was a third conflicting role, although it hadn't caused any groups any issues. One viewpoint was that the majority of Environment Agency employees were anti-hydro and used ecology concerns as an excuse.

"Your recorder can not record the look on my face. Painful is the word and apparently, as far as I know, most schemes have this difficulty... the Environment Agency in its terms of reference if you look on their website, it says something about protecting the environment for the public good or something like that and then it talks about the energy, you know, situation from an environmental point of view, saying we must have more have more renewables and so on and that's a, you know, conflict within the Environment Agency for them." – Interviewee 13A

Interviewees typically felt that the Environment Agency needed to improve their communications and make it clear what their priorities are.

5.5.3 Councils

Community groups have had very different experiences from councils. Councils were largely described as either supportive or a hurdle depending on the attitude of councillors towards climate change or renewable energy. It was frequently described that the council had decided the opposite of what the planning or conservation officers had recommended.

Several groups had had support from the council in the form of a grant or officer support. However this had disappeared following the financial crisis as councils lack funding. One interviewee described how the public sector cuts had slowed down processes as the loss of expertise meant that officers frequently did not know what needed doing. Although one group had wanted to work with the council to come up with a strategic approach for the whole area, the council were not interested.

5.5.3.1 Planning

The majority of groups in the sample had already installed renewable energy projects (i.e. were successful groups) and most had therefore been granted planning permission for at least one project. However gaining planning permission was still viewed with some trepidation by interviewees. One interviewee explained how they had changed their argument to improving energy security when they realised it was more likely to be approved than a project about climate change. Most groups that had received planning permission described that their application for planning permission had received local support. However groups that had not been successful did not comment on local support, but instead commented on the values they believed the council to have, i.e. “not green”.

Planning permission is granted by councils after consideration of the evidence, in particular the advice of the planning officer. It was noted by a large number of groups that they had either been granted planning permission by the council after the planning officer advised against it or had been denied planning permission after the planning officer supported the project. It was uncommon that both the council and the planning officer were in agreement about the project. This suggests that the process may not be suitable for community energy projects.

Some groups had designed the project in such a manner as to avoid requiring planning permission. However interviewees described there was a lot of uncertainty around when planning permission is required. They described that this uncertainty was both internal, i.e. within the community group and external, i.e. the council officers that are employed to answer planning enquires. The uncertainty mostly surrounded what would be allowed as permitted development in a community setting.

5.6 Summary

There are many different factors that have influenced the development of each project and the growth of the sector. These factors are both internal and external.

The community energy sector is often described as incredibly diverse, made to fit the community in which they are implemented. This is true to some extent. However it is clear from this analysis that community groups have had similar experiences and made similar decisions. The rural or urban nature of the projects appears to have had little impact on the project; groups from both settings have similar experiences. The legal structure also appears to have had little impact on the development or outcome of the project. However community groups that do share offers are more likely to form an IPS. Although the age of the group doesn't appear to have any effect on the project, the time at which the community energy project started does, i.e. pre or post feed-in tariffs.

The impact that both national and local governance and statutory agencies have on the sector should not be disregarded. The feed-in tariff is likely to be behind recent growth of the community energy sector as it has provided the potential for these projects to be viable. The feed-in tariff may have unintended consequences. It has affected the installed capacity of the majority of projects, meaning that these projects are not matched to local demand. It has subtly shifted the focus of community energy from reducing the carbon footprint of the area to providing an income stream for the community. This shift in focus could affect how the income is reinvested, which may have an impact on its carbon saving.

The DECC (2014e) study reported that more recent community renewable energy projects are less likely to use grant funding and it is anticipated that this trend will continue. Data were not available to explain this trend. This research also found that newer projects were less likely to have used grant funding. This trend can be explained by two elements:

1. Legislation prevents installations funded through grants qualifying as state aid receiving the feed-in tariff. Since the feed-in tariff was introduced it appears that generating an income for the community has become a central aim of community energy projects – therefore community groups are likely to be unwilling to give up the feed-in tariff if other funding is available.
2. Community groups are struggling to access grant funding, either because it is not available or they are not successful at applying for it. There is however a desire for grant funding to be made available particularly to cover the cost of professional report writing and to provide core funding for employment and office space.

CHAPTER 6 DIRECT CARBON EMISSIONS RELATED TO COMMUNITY ENERGY PROJECTS

This chapter presents the analysis of the direct carbon emissions that community energy projects are responsible for. These are the emissions associated with the project itself, i.e. embodied carbon of the generation technology and those due to offsetting grid electricity. The ability of the community groups to affect the carbon footprint of the project is also assessed by investigating the impact of choices during project development.

The first section contains the project carbon footprint for the community groups that participated in this research. These footprints are used in the second section to look at the effect of technology choice on the direct emission carbon footprint. The third section investigates the impact of installed capacity on the carbon footprint as it was identified that the feed-in tariff banding structure had affected the project size. This section uses theoretical community energy projects with installed capacities that were chosen based on the feed-in tariff bands. The final section investigates the carbon impact of PV panels produced by different manufacturers in terms of country of origin. This was identified as an area of concern for community groups.

6.1 Community groups

This section presents the analysis of carbon emissions due to the project itself. The inventory data for the projects is included in appendix C. This analysis was carried out for all 13 community groups that participated in this research. A total of 14 separate projects are presented. This includes two hydro projects that were abandoned around the time or subsequent to data collection. These projects are included because it was felt that the results would be applicable to other similar projects because they were not abandoned for technical reasons⁴. One of these groups, Sheffield Renewables have since successfully implemented a photovoltaic project. This project is also modelled in this section.

The results are presented in a series of graphs; the same information is shown on a graph for each community energy project. The impact per annum is shown on the left hand axis, whilst the cumulative impact is shown on the right. The impact is shown over a 25 year period, beginning from the approximate month the idea for the project was conceived. There are three aspects of the project represented on the graphs: technology, maintenance, energy generation. Technology includes the manufacture, transport and installation of the energy generation system. This system includes the generation technology itself along with the associated infrastructure, i.e. in the case

⁴ The hydro projects of both Hexham River Hydro and Sheffield Renewables were at a very late stage of development when they were abandoned. This was due to receiving quotations for the work that were much higher than the original predictions. In both cases this was at least partially attributed to late changes requiring the addition of a fish pass as part of the project.

of PV systems it includes roof mounting supports. Maintenance includes manufacture of materials used and transportation of these materials. Energy generation represents the reduction of carbon emissions due to reducing demand for grid electricity, i.e. grid electricity offsetting. The amount of carbon offset by electricity generation reduces over the period of time modelled within the system boundary. This is because in the model the carbon intensity of the grid electricity decreases (see Chapter 3). Projects where PV systems have been installed, the amount of electricity generated also decreases by 1% each year (see Chapter 3).

6.1.1 Crucorney Energy Group

Crucorney Energy Group installed a 9.8kW PV system on their local village hall in March 2011. The direct carbon emissions associated with this project are shown in Figure 6-1. The approximate conception of the project was March 2010. Therefore the installation of the PV system occurs in year 1 of the system boundary. In year 1 the system is responsible for more carbon emissions than it offsets and therefore the annual net impact is positive. In all subsequent years modelled the annual net impact is negative, i.e. more carbon is offset than is emitted. It has been assumed for all PV systems that the inverter is replaced after 15 years following discussions with solar installers. Replacing this part reduces the annual net carbon impact in that year. However a carbon saving is still produced. The group did not plan to undertake any regular maintenance of the system.

The carbon emissions in year 1 are paid back by year 5, when the cumulative net line shows that overall more carbon has been offset than generated. The trend of the cumulative net is negative from year 1 throughout the time period modelled although the annual reduction decreases. This is due to the annual reductions in grid carbon intensity and electricity generation. According to the model this project will offset approximately 39,000 kgCO₂eq by 2034.

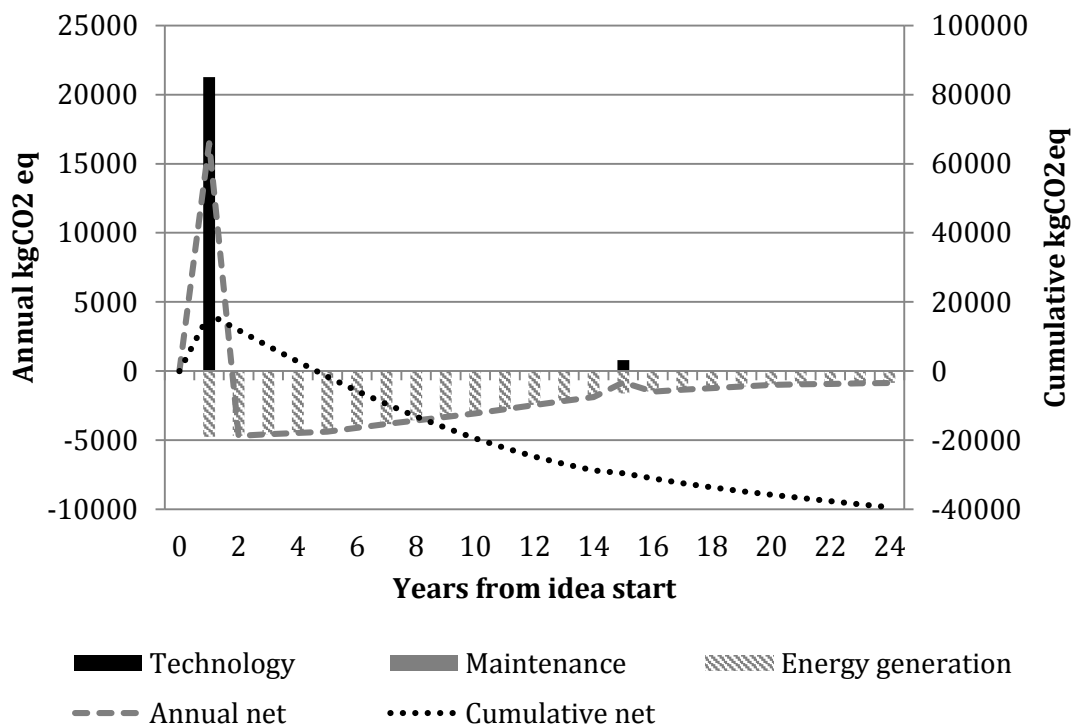


FIGURE 6-1 CARBON IMPACT OF DIRECT EMISSIONS FROM CRUCORNEY ENERGY GROUP'S PROJECT

6.1.2 Easton Community Centre

Three PV systems were installed at Easton Community Centre in July 2012. The total installed capacity of these three systems is 18kW. The direct carbon emissions associated with the systems are shown in Figure 6-2. The project was funded by another community group and so the installation occurred very quickly after the idea was introduced to the centre. The trend displayed is similar to that of the Crucorney project. The model estimates that the Easton Community Centre project will offset 68,000 kgCO₂eq by 2036.

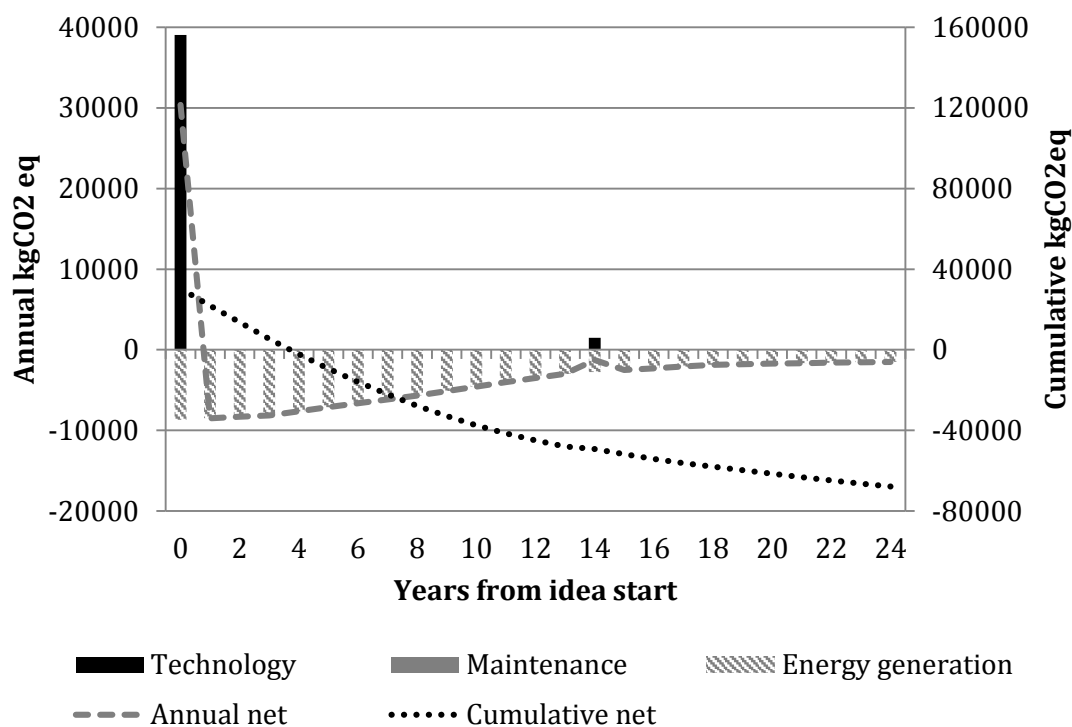


FIGURE 6-2 CARBON IMPACT OF DIRECT EMISSIONS FROM EASTON COMMUNITY CENTRE'S PROJECT

6.1.3 Green Transition Eynsham Area (Green TEA)

Green TEA installed two separate PV systems in the community in 2012. The idea for this project developed around October 2010. One system was placed on the village hall in July 2012 and the other on one of the local churches in March 2012. Together the two systems have an installed capacity of 16.65kW. Figure 6-3 shows the direct carbon emissions associated with the project. The trend displayed is similar to that of the Crucorney project. Approximately 62,000 kgCO₂eq will have been offset by 2034.

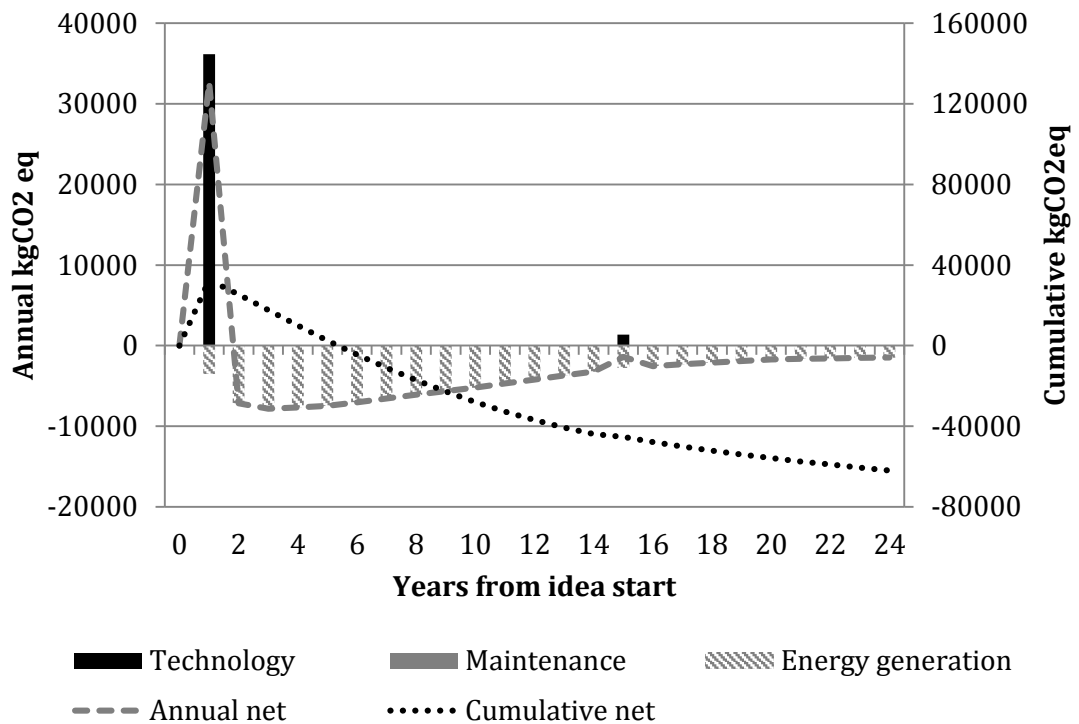


FIGURE 6-3 CARBON IMPACT OF DIRECT EMISSIONS FROM GREEN TEA'S PROJECT

6.1.4 Hebden Bridge Town Hall

Hebden Bridge Town Hall installed a 4kW PV system on their roof as part of redevelopment work. The system was installed in June 2012 after two years of development. The direct carbon emissions associated with the project is shown in Figure 6-4. The trend is similar to that of the Crucorney project. It is estimated that the project will have offset 14,000 kgCO₂eq by 2034.

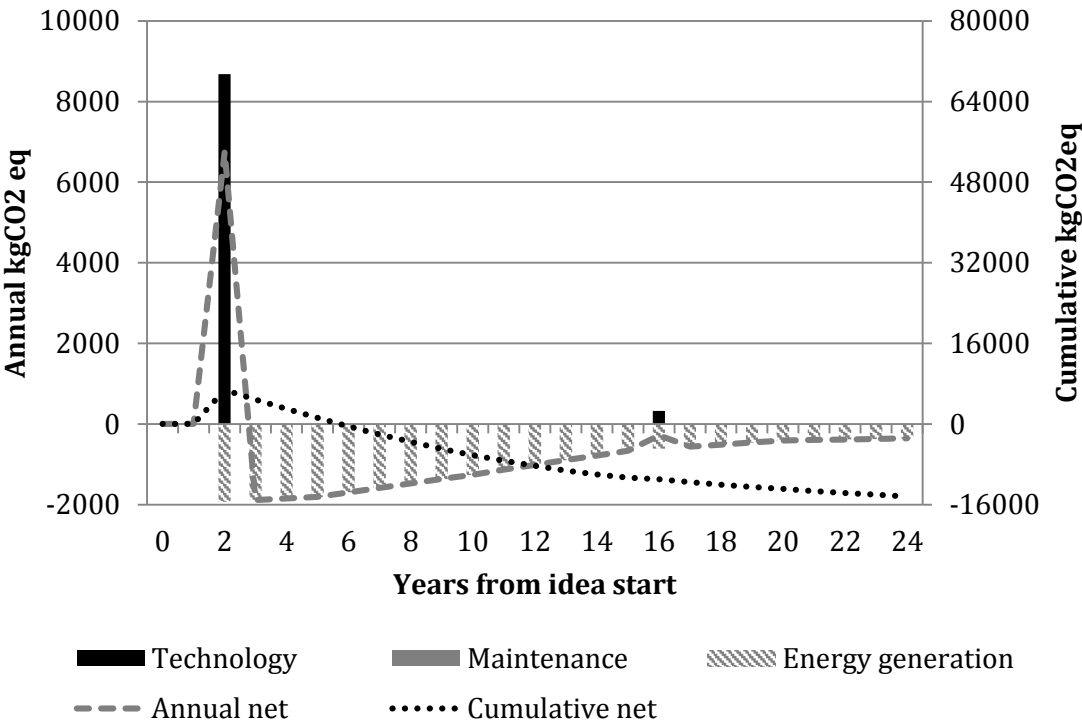


FIGURE 6-4 CARBON IMPACT OF DIRECT EMISSIONS FROM HEBDEN BRIDGE TOWN HALL'S PROJECT

6.1.5 Hexham River Hydro

Hexham River Hydro planned to install a 100kW reverse Archimedes screw. They started working on the project in January 2010. However the project was abandoned in 2013. However the project has been modelled here as if it was installed in January 2015 as it was developed to a fairly late stage and results are likely to be applicable to other hydro projects. The direct carbon emissions that would have been associated with this project is shown in Figure 6-5. The project is shown to be installed in January 2015 – 5 years within the system boundary. The embodied carbon of the technology infrastructure is paid off within the first year of installation. The impact of maintenance has been approximated based on that of a wind turbine taken from the ecoinvent database. This was modelled as 20kg of lubricating oil per annum. Overall maintenance accounts for around 0.0003% of the total impacts. The model predicts that the project will offset 3,300,000 kgCO₂eq by 2034.

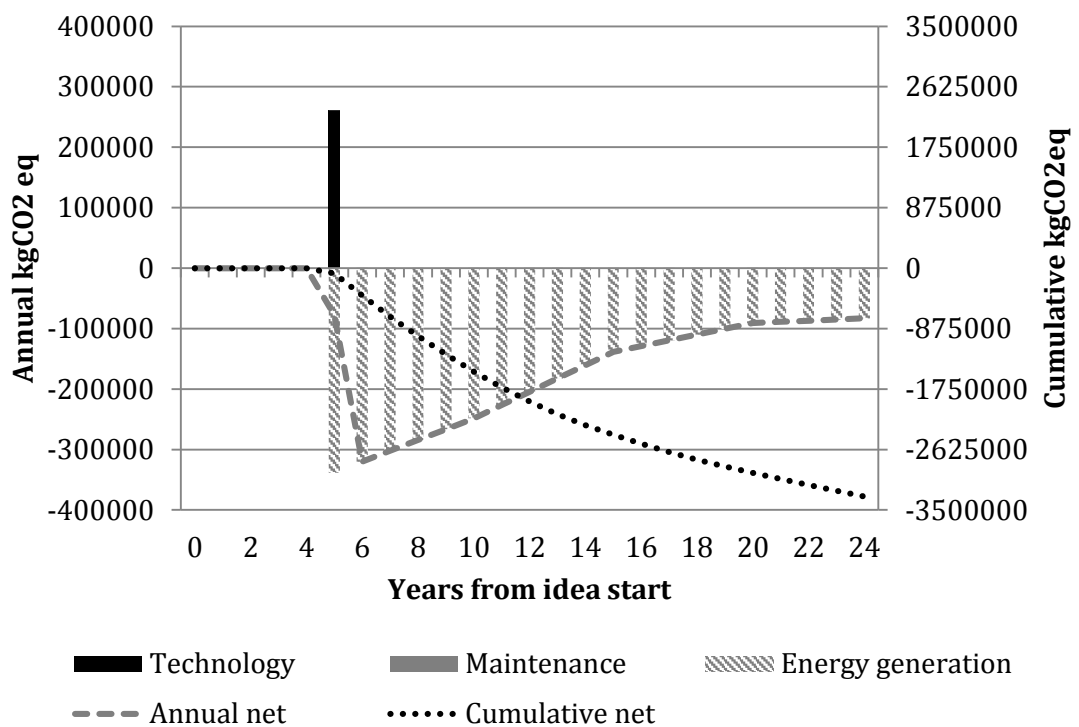


FIGURE 6-5 CARBON IMPACT OF DIRECT EMISSIONS FROM HEXHAM RIVER HYDRO'S ABANDONED PROJECT

6.1.6 Llangattock Green Valleys

A 4.23kW system was installed on a local school in January 2011. The project was conceived in approximately September 2009. Figure 6-6 shows the direct carbon emissions associated with the project. The trend is similar to that of the Crucorney project. The project is estimated to offset 17,000 kgCO₂eq by 2033.

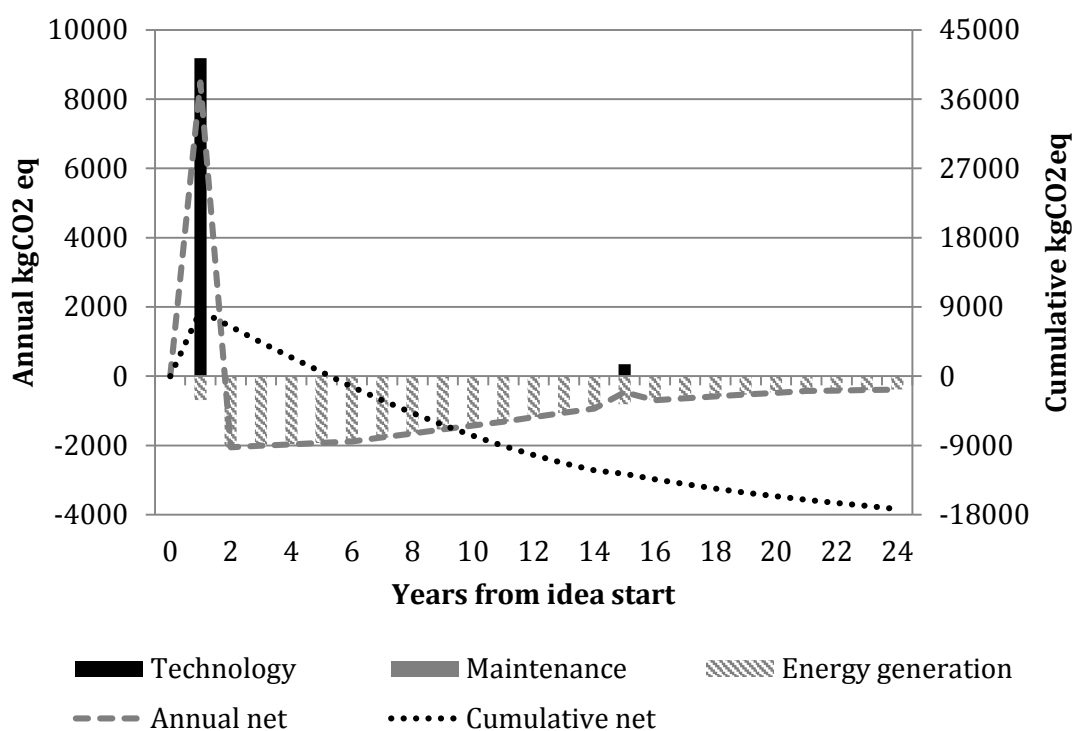


FIGURE 6-6 CARBON IMPACT OF DIRECT EMISSIONS FROM LLANGATTOCK GREEN VALLEYS' PROJECT

6.1.7 Low Carbon Gordano

Low Carbon Gordano has been developing PV projects since the introduction of the feed-in tariff. However most of these projects have not gone ahead due either to changes in the feed-in tariff scheme or due to not gaining permission for the project. During the interview it was identified that they had first started work on a large scale solar farm rather than PV systems on community buildings around November 2012. Although this project did not gain planning permission, it is a similar idea to the project modelled here. Therefore the start date of the idea is assumed to be November 2012. It has been assumed that the installation was completed in January 2015, as this is the date used for all projects yet to be installed.

Figure 6-7 shows the direct carbon emissions associated with the 1875kW PV systems. The trend is similar to that of the Crucerney project. However as this is such a large installation it has been assumed that the panels will undergo yearly maintenance. This maintenance has been calculated at use of 20 litres of water per m² of panel using information from Ecoinvent Centre (2014). Maintenance over the time period modelled accounts for approximately 0.001% of the overall carbon impact. The project is estimated to offset 4,800,000 kgCO₂eq by 2036.

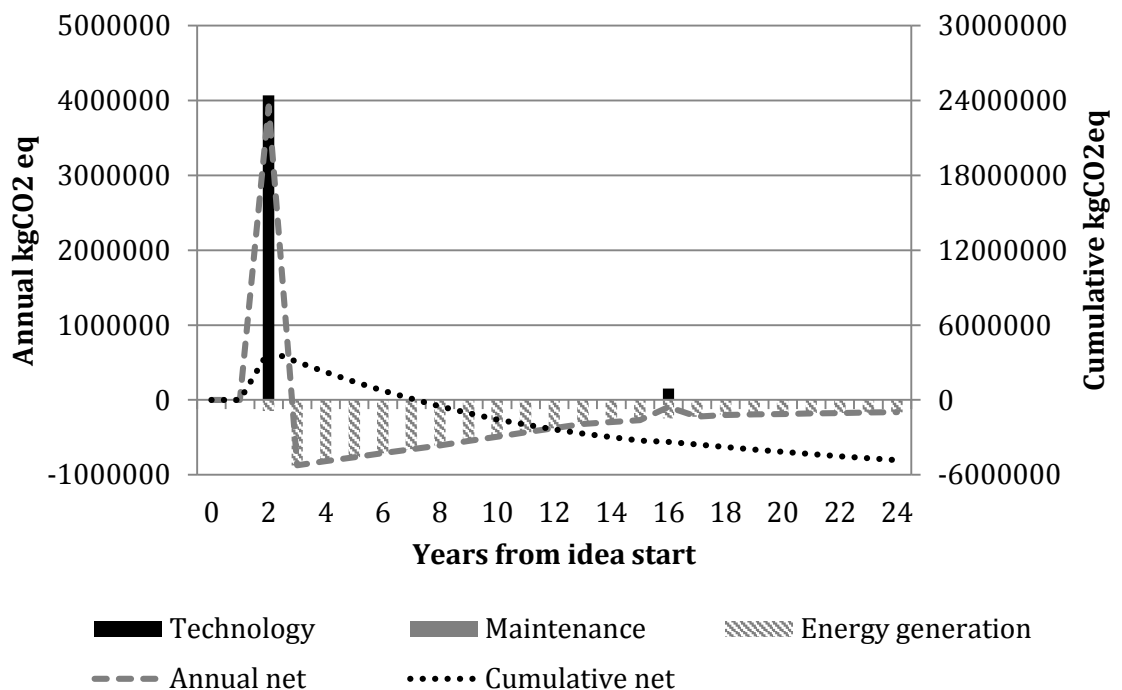


FIGURE 6-7 CARBON IMPACT OF DIRECT EMISSIONS FROM LOW CARBON GORDANO'S PROJECT

6.1.8 OVESCO

This project saw a total of 161.5 kW of PV systems installed across four buildings. The first installation of 98kW on one building took place in July 2011. The remaining three systems were installed between June 2012 and July 2012. The idea for this project developed around July 2010. The carbon impact of these projects are illustrated in Figure 6-8. This trends of this project is similar to that of Low Carbon Gordano's project as it was indicated in the interview that the panels were maintained by washing them. There is a double peak for technology in years 1 and 2 and again in 15 and 16 because the project was installed over two years. The model estimates that the project will offset 620,000 kgCO₂eq by 2034.

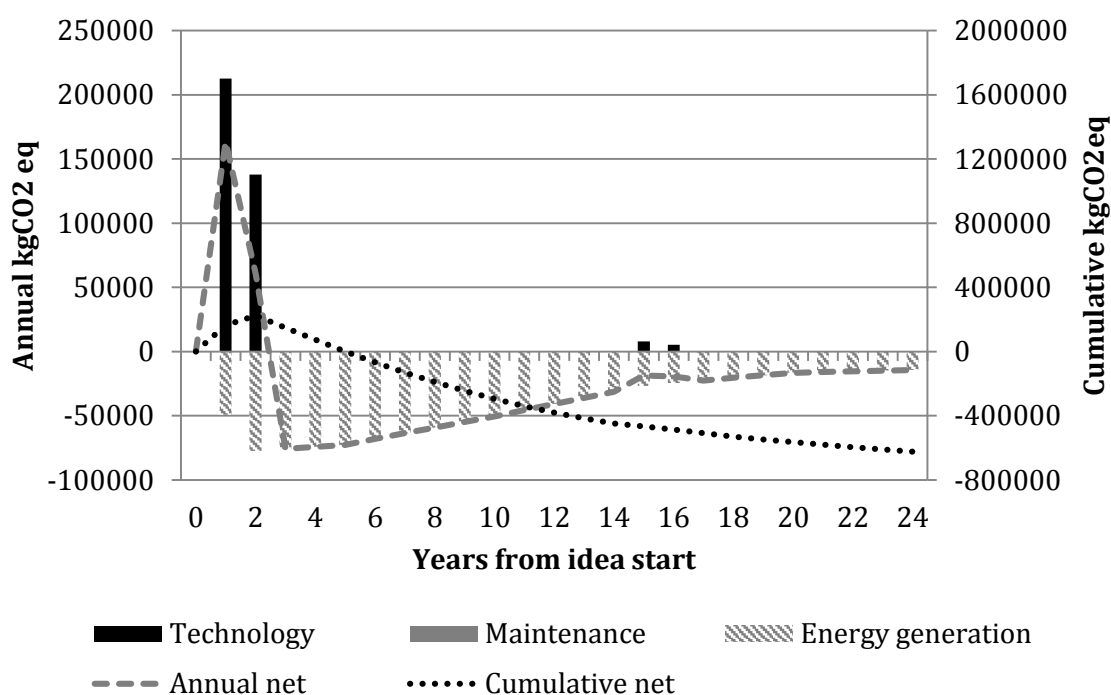


FIGURE 6-8 CARBON IMPACT OF DIRECT EMISSIONS FROM OVESCO'S PROJECT

6.1.9 Pennine Community Power (PCP)

A 10kW wind turbine was installed by Pennine Community Power in October 2012 after approximately 6 months of development. Figure 6-9 shows the carbon impact of the direct emissions from this project. The embodied carbon of the wind turbine is lower than that of an equivalent sized PV system. The project pays back its embodied carbon during the first year of installation. Maintenance has been approximated as use of 2kg of lubricating oil per year (scaled from Eco invent data). Maintenance accounts for approximately 0.03% of the carbon impact modelled. The project has been estimated to have offset 620,000kg kgCO₂eq by 2036.

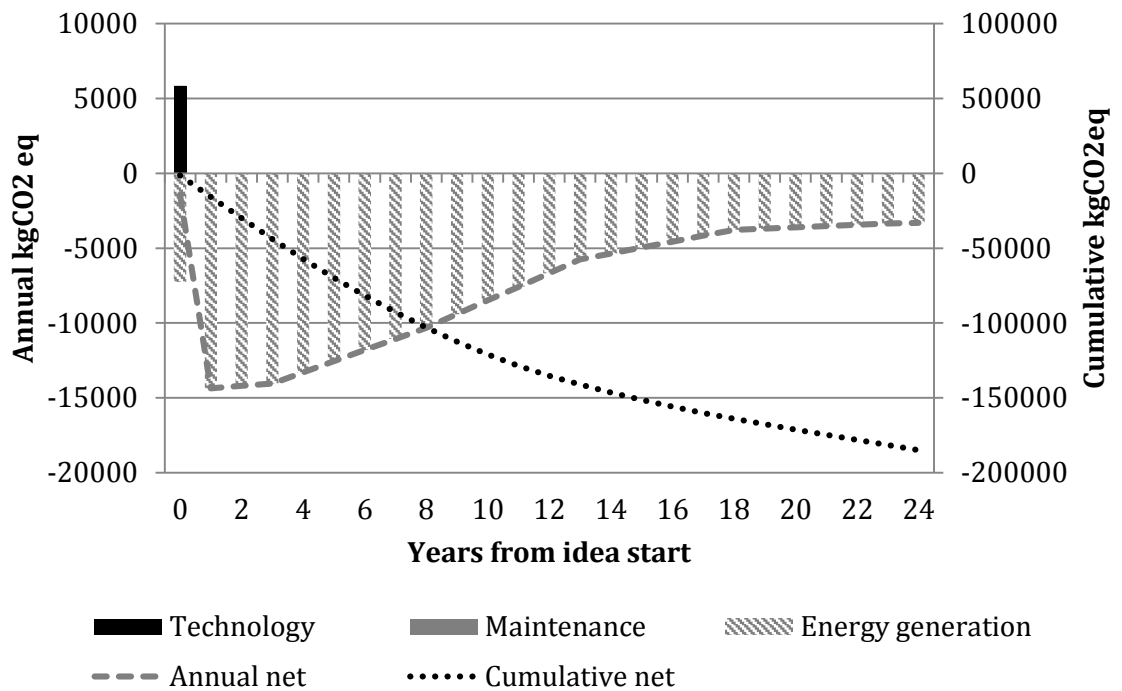


FIGURE 6-9 CARBON IMPACT OF DIRECT EMISSIONS FROM PCP'S PROJECT

6.1.10 Sheffield Renewables

Sheffield Renewables had developed a hydro project almost to the point of starting installation before halting the project around the time of interview. The group had just started development of a PV project. This PV project was then installed in April 2014. Therefore both projects have been modelled in this research.

6.1.10.1 Hydro

Sheffield Renewables started developing an 80kW reverse Archimedes screw in November 2008. The project was halted in 2013. For modelling purposes it has been assumed that the project was installed in January 2015. Figure 6-10 shows the direct emissions associated with the project. The trend is similar to that of Hexham River Hydro, although the project is installed in year 6. It is estimated that the project will have offset 1,800,000 kgCO₂eq by 2032.

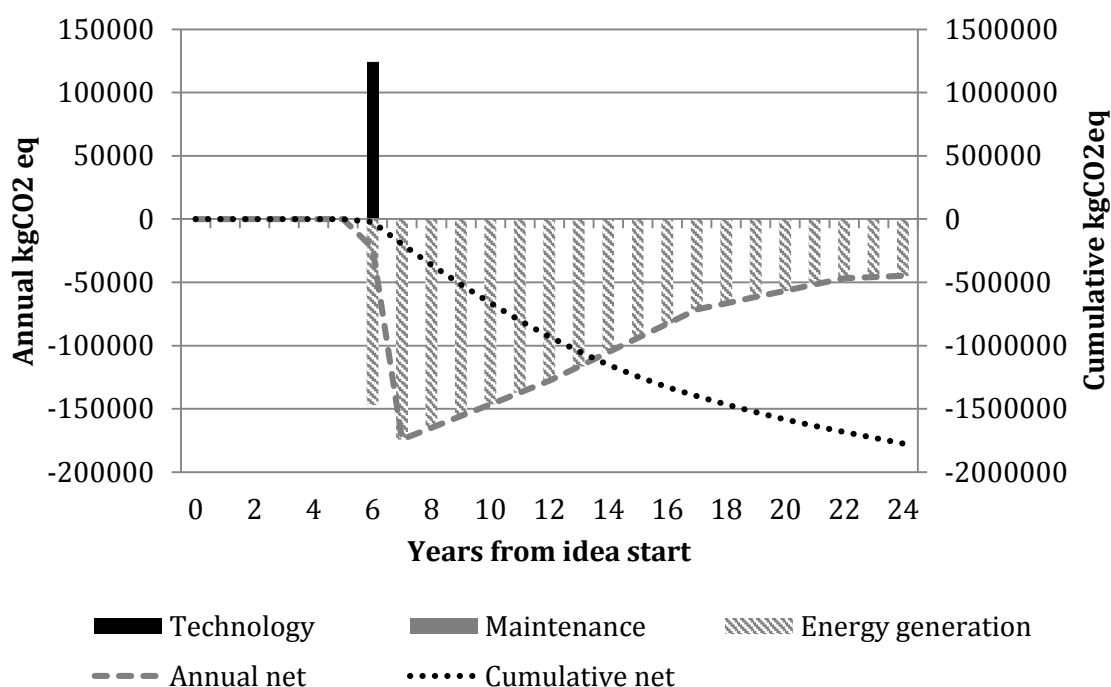


FIGURE 6-10 CARBON IMPACT OF DIRECT EMISSIONS FROM SHEFFIELD RENEWABLE'S HYDRO PROJECT

6.1.10.2 PV

Sheffield Renewables installed a 50kW PV system on a community building in April 2014. It was estimated that the idea had started in April 2013, around the time of the interview. The direct carbon emissions associated with the project is shown in Figure 6-11. The trend is similar to that of the Crucorney project. It is estimated that the project will have offset 150,000 kgCO₂eq by 2037.

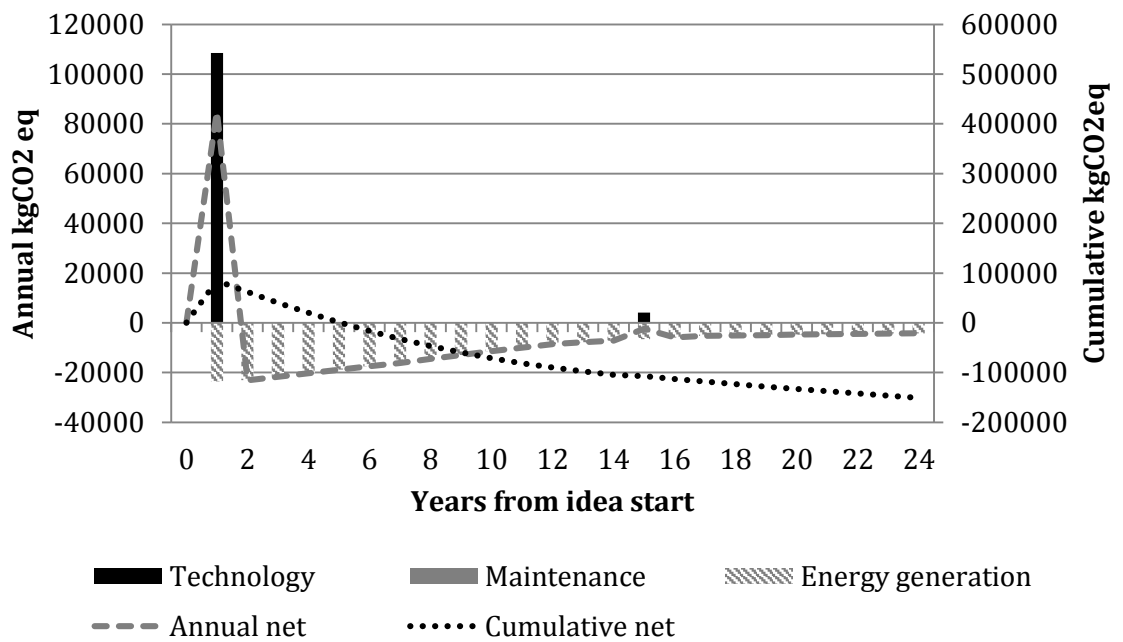


FIGURE 6-11 CARBON IMPACT OF DIRECT EMISSIONS FROM SHEFFIELD RENEWABLE'S PV PROJECT

6.1.11 Snitterfield Actioning Climate Change

Three 3.8kW PV systems were installed on community buildings between December 2011 and July 2012. The idea for this project was conceived in October 2010. Figure 6-12 presents the carbon impact of the project. The trend is similar to that shown by the Crucorney Energy Group project. It is estimated that this project will have offset 42,000 kgCO₂eq by 2034.

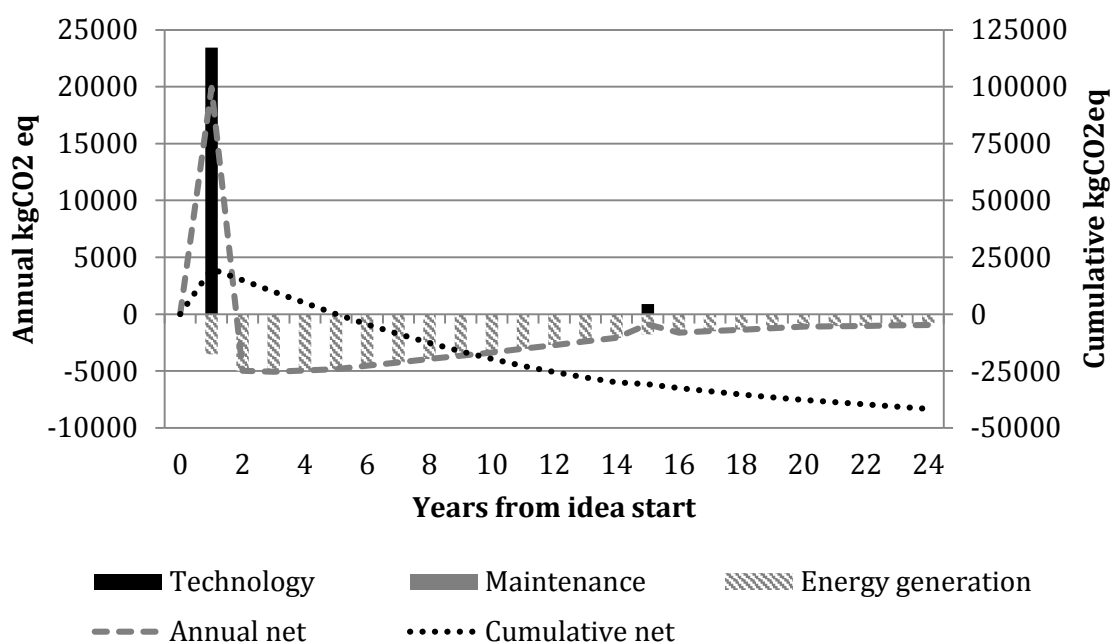


FIGURE 6-12 CARBON IMPACT OF DIRECT EMISSIONS FROM SNITTERFIELD ACTIONING CLIMATE CHANGE'S PROJECT

6.1.12 Talybont on Usk Energy

In April 2006 a 36kW hydroelectric turbine was installed at a reservoir for Talybont on Usk Energy's project. This was after approximately 3 years development. The carbon impact of the project is shown in Figure 6-13. This project has been modelled as if it was a reverse Archimedean screw as this was the closest data available. The trend is similar to that of the Hexham River Hydro project. It is estimated that this project will have offset 2,400,000 kgCO₂eq by 2027.

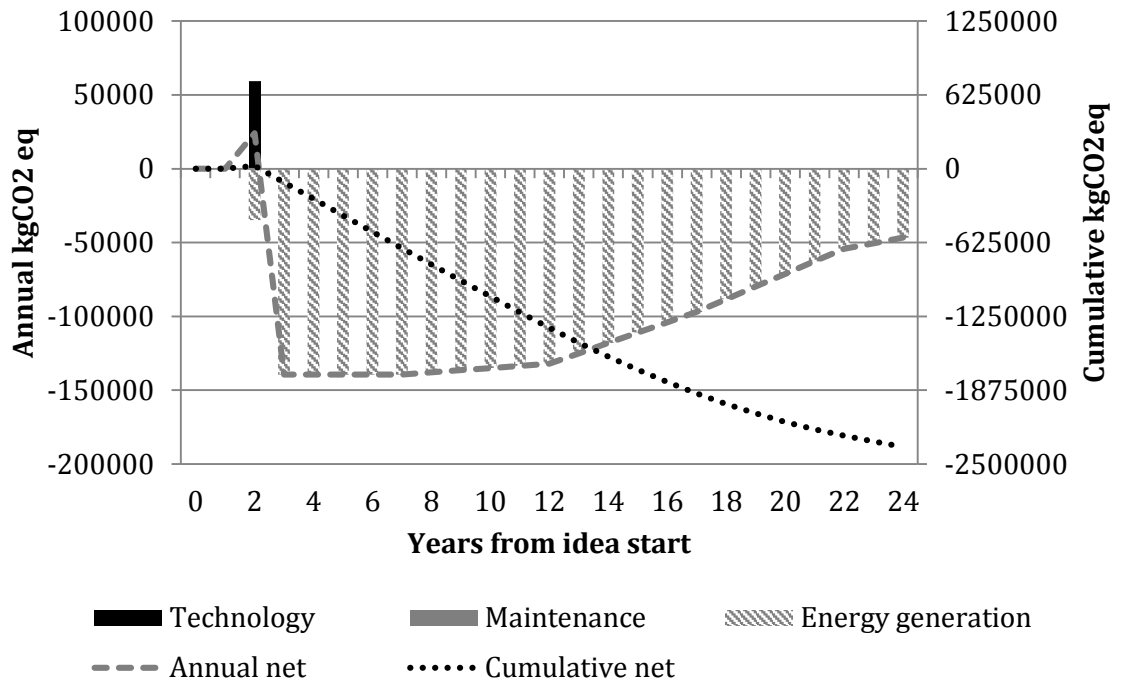


FIGURE 6-13 CARBON IMPACT OF DIRECT EMISSIONS FROM TALYBONT ON USK ENERGY'S PROJECT

6.1.13 Whalley Community Hydro

A 100kW reverse Archimedes screw was installed in approximately November 2014. Development of this project started in February 2010. Figure 6-14 shows the carbon impact associated with the project. The trend is similar to that of Hexham River Hydro’s project. The project is estimated to offset 1,900,000 kgCO₂eq by 2034.

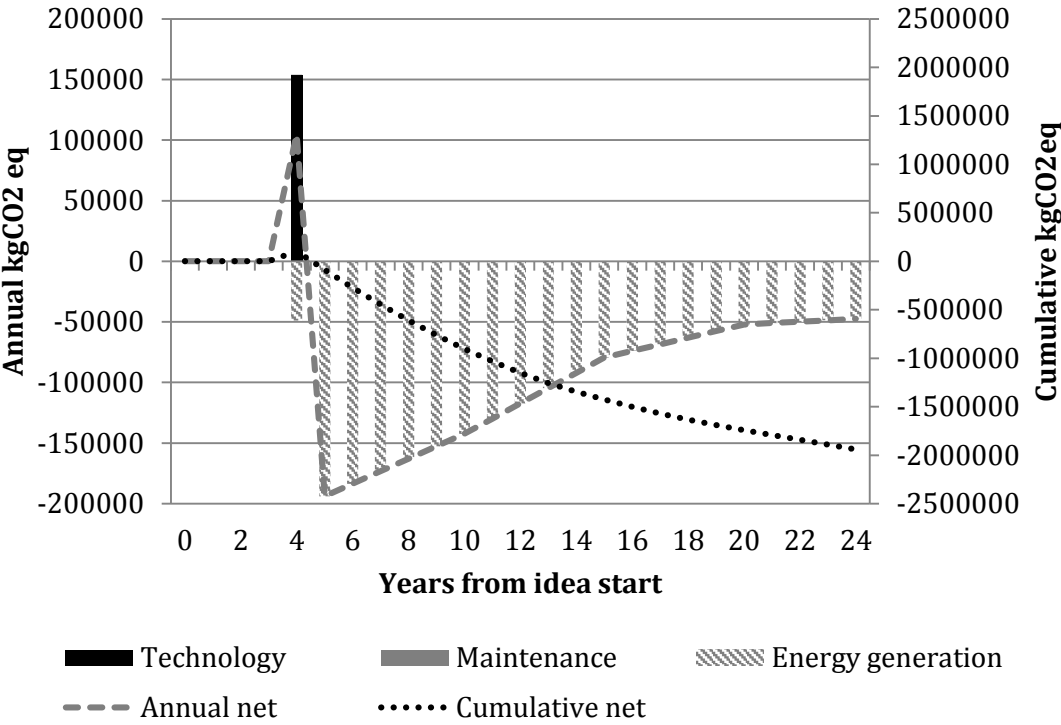


FIGURE 6-14 CARBON IMPACT OF DIRECT EMISSIONS FROM WHALLEY COMMUNITY HYDRO'S PROJECT

6.2 Technology

Reasons behind technology choice were analysed in Chapter 5. The carbon footprint of the technology was not one of the reasons specified by any of the interviewees. This ties in with findings by DECC (2012d) and Platt et al. (2011). The effect of technology choice on the direct emission carbon footprint is illustrated in Figure 6-15. This figure shows the carbon savings modelled for the projects presented in the previous section against the installed capacity of each project. The different technologies are represented by different markers.

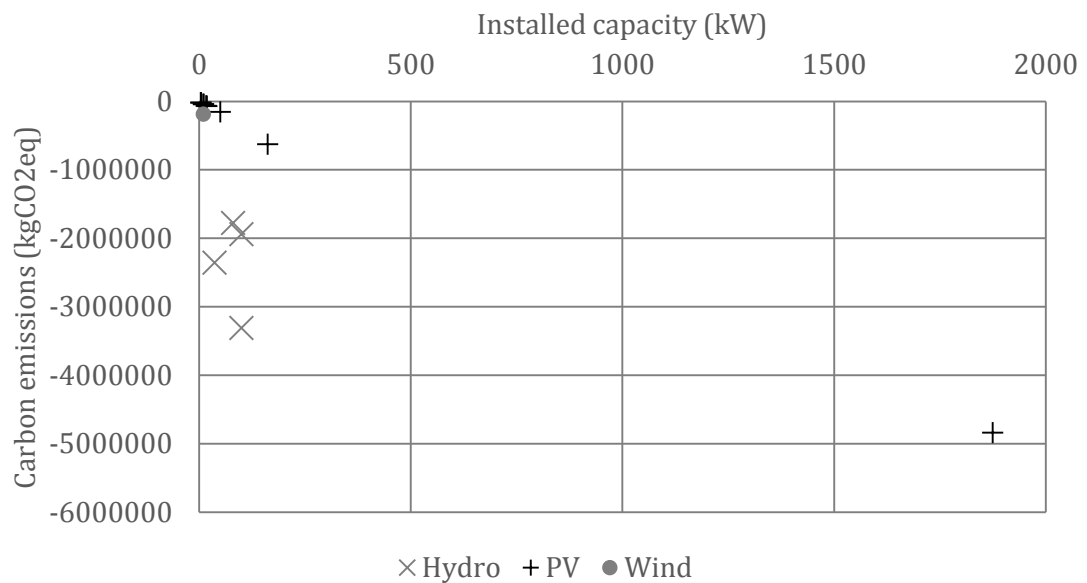


FIGURE 6-15 PROJECT COMPARISON SHOWING TYPE OF TECHNOLOGY INSTALLED

There is only one example of a wind project in this research and so the rest of this section focuses on the comparison between PV and hydro projects. PV projects are typically smaller than hydro projects and offset less carbon. However when comparing projects of a similar installed capacity, PV offsets around half of that which a hydro project would offset. This is despite the longer lead in time of hydro projects. Hydro projects took approximately 48 months from idea to generation (this figure does not include the two projects that have been abandoned or halted). PV projects took approximately 15 months to install (this figure does not include the project that is yet to be completed so may be an underestimate). This is largely because the carbon payback period of PV is longer than that of hydro; the payback period of PV is approximately four years, for Archimedes screws it is less than one year.

However the hydro projects in this analysis are all a similar size, no projects are larger than 100kW. Two projects have not gone ahead because the costs involved with projects of this size were felt to be too high and create too high a risk for community groups. Therefore it is possible that this may represent the maximum scales of community hydro. If this were the case then PV has the potential to save more carbon than hydro projects by installing larger projects.

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This research did not aim to recruit community groups where at least one project had failed, however during the research process some evidence of this type of project was collected. It is not clear if more hydro projects fail than PV projects. However failed hydro projects may be more apparent than PV projects because of the limited availability of hydro sites compared to PV sites. Groups where one PV site had fallen through often transferred the project to another site.

6.3 Installed capacity

The effect of installed capacity on the carbon saving potential of the three types of technology installed by the case studies is investigated in this section using theoretical models. The main factor affecting choice of installed capacity for photovoltaic systems identified in Chapter 5 was the banding structure of the feed-in tariff. A number of minor factors were also identified as: visual appeal and matching local demand. Wind systems were influenced by conditions imposed by planning officers. Hydro systems however were typically designed to match site potential generation.

6.3.1 Photovoltaic systems

The following analysis is based on polycrystalline (multi-Si) panels from the Ecoinvent 3.0.1 database. This is because this is the style of panel that had been installed by those groups that knew what had been installed. The different sizes for comparison have been selected on the basis of the banding structure of the feed-in tariff. The final band covers all installations greater than 250kW. Therefore in order to create an installation that lies in this band a 500kW system has been modelled.

It has been assumed that the panels are manufactured and installed on the first day of year 0 – this is modelled as 1st January 2010. Maintenance has not been included as the majority of groups indicated they did not plan regular maintenance. Analysis of the community projects in the first section indicated that maintenance was of minimal significance to the carbon footprint. Panels installed on a roof are based on a slanted roof 3kW system. Ground mounted systems are based on a 570kW ground mounted system. In both types of system it has been assumed that the inverter is replaced after 15 years of operation. The inverter for systems up to 10kW is based on a scaled 2.5kW inverter. Above 10kW the inverter is based on a scaled 500kW inverter.

It has been assumed for all systems that annual generation is 830kWh per kW installed capacity, with an annual degradation of 1% see Equation 6-1. The carbon intensity of the electricity offset by the systems is based on work produced for the Transition Pathways project and represents the Thousand Flower pathway (see Chapter 3).

EQUATION 6-1 REDUCTION IN ANNUAL GENERATION OF 1KW PV SYSTEM

$$Generation(year) = 830 \times (1 - (year \times 0.01))$$

Figure 6-16 shows the cumulative carbon emissions associated with the seven modelled systems, compared for 1kW of installed capacity. It can be seen that the size of the installation has little effect on the associated carbon emissions. There is little significant difference between systems mounted on a roof compared to ground mounted systems shown by this analysis. However the difference between roof and ground mounted systems is due to the carbon impact of land use change – it may therefore not represent the impact of all ground mounted systems.

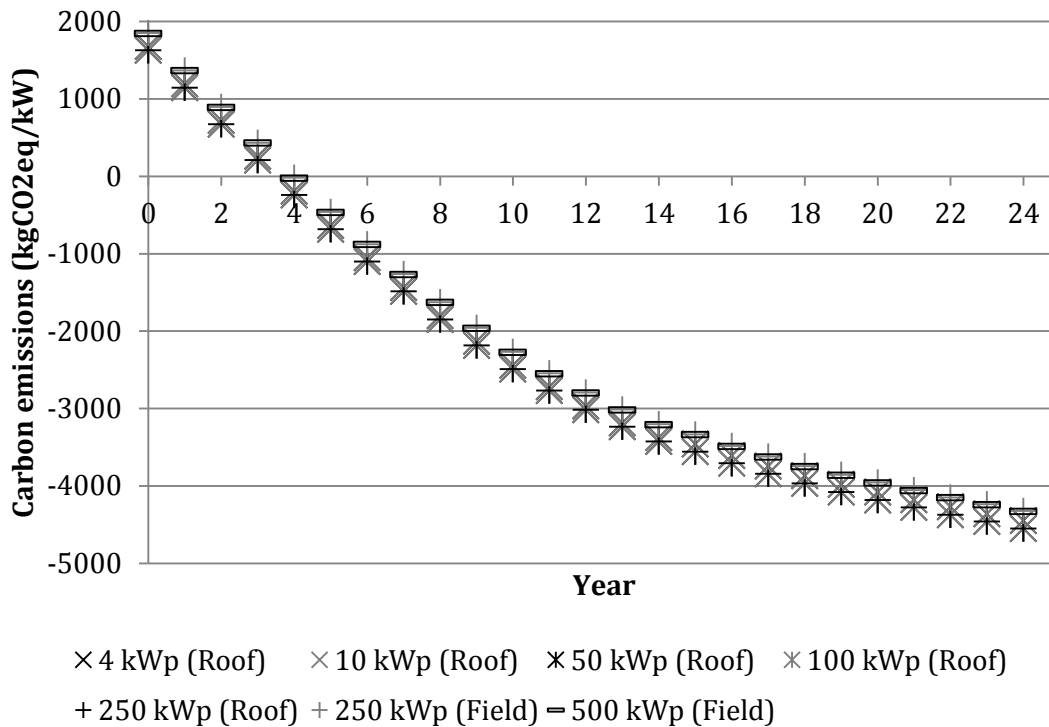


FIGURE 6-16 CUMULATIVE CARBON EMISSIONS PER KW INSTALLED CAPACITY OF PV SYSTEMS

6.3.2 Wind turbines

This analysis is based on two wind turbines within the Ecoinvent 3.0.1 database: 800kW turbine and 2MW onshore turbine. These turbines have been scaled to produce the required rating. The different sizes for comparison are based on the feed-in tariff bands, using the same end point condition as the PV analysis. Two versions of the 1.5MW turbine have been created, one for each size of turbine as the scaling is similar for both. Maintenance is not included.

EQUATION 6-2 ANNUAL POWER GENERATION OF A WIND TURBINE IN W. $C_p = 0.4$, u = WIND SPEED AND A = SWEEPED AREA OF BLADES, ρ (AIR DENSITY) = 1.225

$$P_{\text{annual}} = \frac{1}{2} \rho A u^3 C_p \times 24 \times 365 \times 0.3$$

The average annual generation of each turbine has been calculated using Equation 6-2. This method underestimates the annual generation compared to that predicted by the Wind Power Programme⁵ (40% for 2MW turbine, 20% for a 5kW turbine). The SAP 2012 method requires the rotor diameter. The average rotor diameter for each size of turbine was calculated based on real turbine specifications⁶. The wind speed at 10m above ground level has been assumed to be 5m/s in an

⁵ <http://www.wind-power-program.com/>

⁶ Turbines less than 15kW were based on those on the Microgeneration Certification Scheme database. Turbines above 15kW were based on turbines found during an internet search for turbines of specific ratings. This is shown in appendix C, Table C.5

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urban area. The wind speed at the tower height was calculated using Equation 6-3 from (Kaltschmitt et al, 2007). The tower height was found in the same method as the rotor diameter.

EQUATION 6-3 WIND SPEED (V_{th}) AT TOWER HEIGHT (h_{th}) AT AN URBAN SITE WITH A WIND SPEED OF 5M/S AT 10M, 0.34 IS HELLMANN EXPONENT AND IS BASED ON NEUTRAL AIR ABOVE HUMAN INHABITED AREAS

$$V_{th} = 5 \times \left(\frac{h_{th}}{10} \right)^{0.34}$$

Figure 6-17 shows the cumulative carbon emissions associated with 1kW of installed capacity for the different wind projects modelled for this section. The smallest turbines pay back the embodied carbon within two years. For larger turbines the embodied carbon is paid back within a year. The carbon emissions associated with 1kW of different sizes of wind turbine varies. Smaller turbines typically reduce carbon emissions by a smaller amount than larger turbines. This is largely due to the effect of higher wind speeds at higher altitudes. However the 100kW turbine appears to perform better than both the 500kW turbine and 1500kW turbines. Lower rated turbines generate more energy per kW than higher rated turbines under the same wind conditions. In this region it appears that the increase in wind speed with height does not overcome this difference.

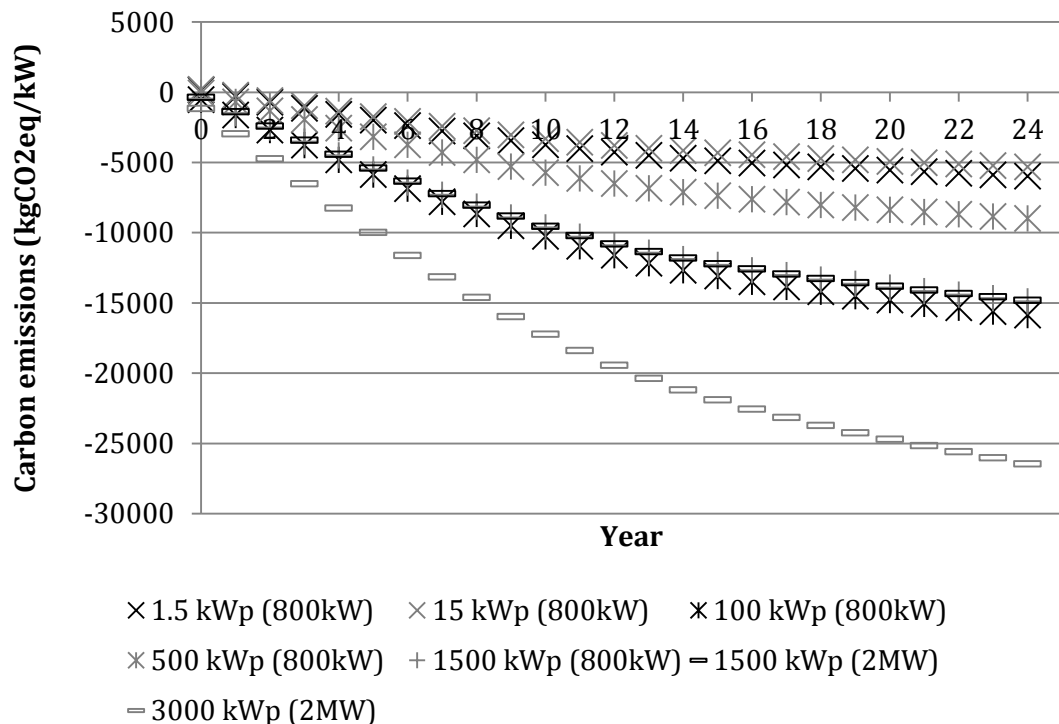


FIGURE 6-17 CUMULATIVE CARBON EMISSIONS PER KW INSTALLED CAPACITY OF WIND SYSTEMS

6.3.3 Hydro systems

There are several types of hydro system in use in the UK at the present time: reservoirs, pumped storage and run of river systems. One group, Talybont On Usk, have a hydro system that uses the outflow of a reservoir. However this was only possible due to the unique circumstances surrounding the site. The water company that built the reservoir had originally used the site to generate power.

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When they stopped using the site they left the infrastructure in situ, which meant it was relatively simple for the community group to restart generation at the site. The group were unsure that they would have been allowed to take over the site in the current market.

The remaining groups in the sample who planned hydro systems were all planning run of river systems based around existing weirs. Therefore this analysis is based on run of river systems as it is a closer reflection of the current developments in the field. There are many types of run of river turbines, for example, Kaplans, Peltons and Reverse Archimedes Screws etc. Most groups are planning to install Reverse Archimedes Screws and there are indications that the Environment Agency will only give permission to this type of turbine (personal communication, 2013).

Figure 6-18 shows the cumulative carbon emissions of different sized hydro systems. Whilst the comparison of different sized PV and wind systems assumed that they were installed at the same site, for hydro it has been assumed that each system is installed in an optimum site with a head of 1.75m (i.e. the flow rate has been allowed to vary) using Equation 6-4 from Lubitz (2014). This is because hydro systems are currently designed and manufactured bespoke for the site.

EQUATION 6-4 POWER OUTPUT, $P = 1000$, $g = 9.81$, Q = FLOW RATE, H = HEAD, η = EFFICIENCY

$$P_{available} = \rho_{water} \times g \times Q \times H \times \eta$$

The embodied carbon is much smaller (approximately 40%) of carbon offset by generation in the first year. The difference in embodied carbon of different systems is therefore eclipsed by the impact of generation. Therefore the carbon emissions associated with 1kW of hydro system is independent of size of installation. As there is some difference in embodied carbon however this may change over time as the carbon emissions from the grid decrease.

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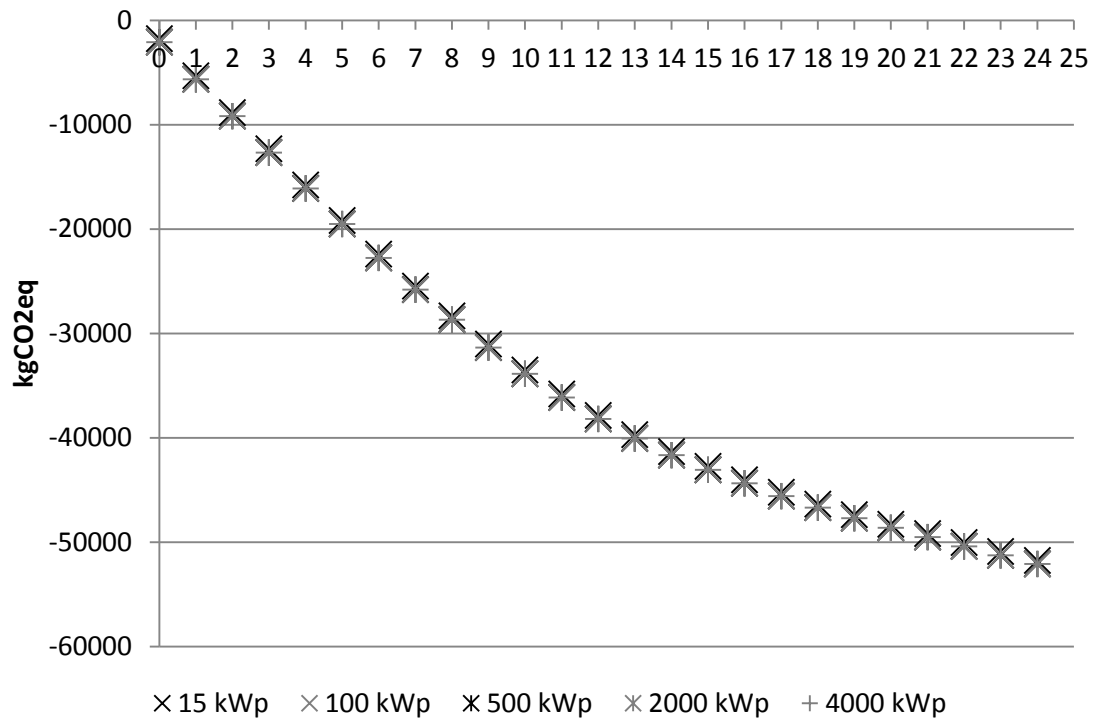


FIGURE 6-18 CUMULATIVE CARBON EMISSIONS PER KW INSTALLED CAPACITY OF HYDRO SYSTEMS

6.4 Manufacture

From the interviews it was identified that groups that carried out hydro or wind projects were limited to a small number of suppliers of the technology. In the case of wind turbines, groups that wish to qualify for the feed-in tariff are limited to turbines that have been certified under the Microgeneration Certification Scheme. Although the same restrictions do not apply to hydro projects, there are a limited number of manufacturers.

There is a larger choice of manufacturers of photovoltaic systems however. When groups were asked about their choice of manufacture it was linked principally to the country in which they were based rather than any knowledge about the features of a particular brand. The impact of different countries of origin on the embodied carbon for PV is therefore investigated in the following two sections. The first looks at the difference due to energy mixes in different countries. The other section looks at the impact of transportation due to concerns over locality. Embodied carbon in the PV system accounts for between approximately 26% and 31 % of the carbon footprints of projects modelled in this research.

6.4.1 Manufacturing process

Panel manufacture can be broken into 5 distinct production processes: Metallurgical grade silicon, poly silicon, wafer, cell, panels. The production contribution towards the global market from each country was published in Dominique Ramos (2010). This work has been used to calculate the embodied carbon of a 1kW panel created from this global market. In this panel, electricity accounts for around 50% of the embodied carbon. Scenarios of minimum and maximum embodied carbon due to electricity were created. These were based on countries with the highest and lowest carbon emissions due to their electrical grid mix, where that stage of manufacture takes place shown in Table 6-1. The results are shown in Figure 6-19. This graph indicates that the country of manufacture can have a significant impact on the embodied carbon of a panel, potentially reducing the impact by 56% or increasing it by 129%. This has an impact on the carbon payback period of the panel: average 4.3 years, min 2.4 years, max 5.6 years.

DIRECT CARBON EMISSIONS RELATED TO COMMUNITY ENERGY PROJECTS

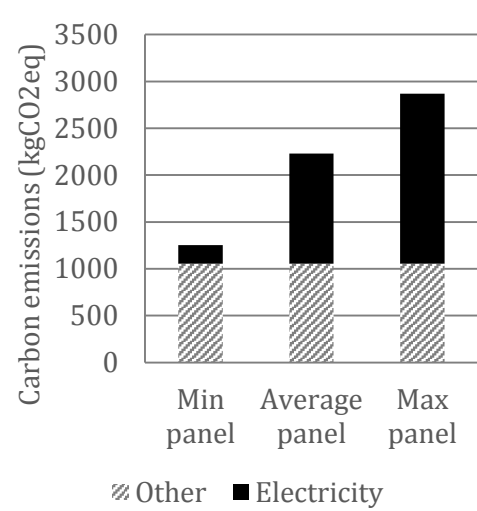


TABLE 6-1 COUNTRY OF MANUFACTURE FOR MINIMUM AND MAXIMUM EMBODIED CARBON

Process	Min County	Max Country
MG-Si	Norway	China
Poly-Si	Canada	China
Wafer	Norway	China
Cell	Australia	India
Module	Australia	India

FIGURE 6-19 CARBON EMISSIONS DUE TO MANUFACTURE OF A 1KW PV PANEL

6.4.2 Transportation

Transportation is responsible for less than 1% of embodied carbon. Different transport routes are therefore limited in the impact they will have on the overall impact of PV. The likely transport route of silicon up the supply chain was modelled for two different manufacturers with very different supply chains shown in Table 6-2 - Table 6-3. These routes were calculated using information on supply chains collected from company websites and news articles. It was assumed that only one company supplied the next in the supply chain due to constraints on time. Where information about the supply chain was unavailable it was assumed that the company was supplied according to the worldwide output from the preceding stage, published by Dominguez-Ramos et al. (2010). Routes were identified to minimise the amount of road transport required and rail transport was not considered due to cost constraints acquiring freight rail network information. Distances travelled on this route were calculated using Google Maps (2013). Shipping routes were assumed to be direct between two ports as not enough information is available about typical shipping routes. The Sea Rates (2013) website was used to calculate for port to port distances. The transport routes were modelled using Ecoinvent 2.0 transport processes.

The route for manufacturer 1 was responsible for around 7kgCO₂eq and the route for manufacturer 2 for around 14kgCO₂eq. The small difference between the two routes is because most of it occurs by sea with has a very low carbon footprint. This further limits the effect that different transport routes have on the overall carbon impact of PV.

TABLE 6-2 TRANSPORT ROUTE OF MANUFACTURER 1

Manufacturer 1	Sea (km)	Road (km)
MG silicon --> Polysilicon	7000	1000
Polysilicon --> Wafer	0	2000
Wafer --> Cell	2000	60
Cell --> Module	20000	70
Module --> Installer	0	400
Installer --> Community	0	1

TABLE 6-3 TRANSPORT ROUTE OF MANUFACTURER 2

Manufacturer 2	Sea (km)	Road (km)
MG silicon --> Polysilicon	10000	2000
Polysilicon --> Wafer	10000	600
Wafer --> Cell	0	0
Cell --> Module	0	0
Module --> Installer	20000	200
Installer --> Community	0	8

6.5 Summary

Models of the community energy projects show that all projects lead to a reduction in carbon emissions due to the project. However the reduction is linked to the grid carbon intensity of the energy system; as this reduces the reductions due to the projects also reduce. In the future therefore this statement may not apply. This is likely to affect PV projects first due to the high embodied carbon present in these systems.

Hydro power has the largest carbon reductions per kW of the three technologies in this analysis. This is despite taking the longest time to start generating from the conception of the idea. This is due to the low carbon payback period and because hydro projects are designed to the conditions present at the site. Site conditions are largely ignored for PV and wind is influenced by planning officers. However PV projects have the potential to have a higher installed capacity than hydro projects and therefore some PV projects may reduce more carbon than hydro projects.

The installed capacity of the project has little impact on the carbon impact per kW with the exception of wind turbines. The group that had installed a wind turbine indicated that the size of the turbine had been limited by the planning officer.

Some community groups selected the PV panels for their project based on the country of origin. A simple analysis suggests that this can make a difference to the carbon footprint of the project. However this is due to the high electricity consumption during production and the regional variation in grid carbon intensity. Transportation costs are largely irrelevant due to the low contribution of this aspect towards embodied carbon.

CHAPTER 7 INDIRECT CARBON EMISSIONS RELATED TO INCOME USE

This chapter presents an analysis of the potential carbon impact of the use of the income stream generated by community energy projects. This chapter is based on information extracted from the interviews carried out with the community groups, backed up with information publically available on the community groups' websites. A list of these websites is available in Chapter 3.

The first section describes how the income stream is generated and how it is used. The second section sets out the methodology used to model the carbon impact of the income stream. The final section presents the results of the analysis for each community energy project.

7.1 Income stream

In Chapter 5 it was identified that the feed-in tariff scheme, introduced in October 2010 was the main source of funding for community energy projects. The feed-in tariff scheme provides a guaranteed generation tariff rate for each unit of electricity generated and a guaranteed export rate for each unit of electricity exported to the grid. At the point the scheme was introduced the rates were guaranteed for 25 years. In August 2012 this was reduced to 20 years for new projects (OFGEM, 2014b).

The generation tariff rate is set at the time the project is registered with the scheme and is based on the type of technology and the size of installation. The rate is regularly decreased so that new installations receive a lower rate than older installations. Once the rate is set for a particular scheme, it then increases annually in line with the retail price index (RPI). In April 2012 an additional criteria was added to the scheme for PV installations. The EPC rating of the building is taken into account to calculate the rate received. However this criterion is not applied to projects run by community groups (OFGEM, 2014b)

The export rate is also set at the time the project is registered. However it is the same for all projects regardless of technology or size. The export rate was initially 3.2p per unit. This was increased to 4.5p per unit for PV on the 1st August 2012 and for non-PV on 1st December 2012. The export rate also increases in line with RPI. Projects with an installed capacity below 30 kW are assumed to export a set amount of electricity to the grid. For hydro projects it is assumed that 75% of the electricity is exported, for other projects it is assumed that 50% is exported. The electricity actually exported is measured for projects over 30kW (OFGEM, 2014b). The export rate under the feed-in tariff scheme provides a guaranteed rate. However groups may be able to get a higher rate for energy exported by entering into a power purchase agreement with an energy supplier.

Projects that have more than 50kW of installed renewable energy capacity in one system are eligible to register to receive Climate Change Levy Exemption Certificates (LECs). These certificates can be sold to energy suppliers at a rate agreed between the community group and energy supplier.

The energy supplier then uses these certificates as evidence that they are using sources of generation exempt from the Climate Change Levy (CCL) tax (OFGEM, 2014a).

The majority of groups interviewed for this research provided or planned to provide the electricity to the building through which it connected to the grid for free. This was either to support the community building or if on a privately owned building, secure the space rent free. However one group was planning to sell the electricity to the community building at a rate below market rate as they felt this was the only way that the project would be financially viable due to the reduction in feed-in tariffs. Although this group ended up doing a different project, another group who installed a similar project at a similar time do sell the electricity to the community building. The groups can only sell electricity to a building that they have not exported to the grid.

7.1.1 Income use

It was identified in Chapter 5 that community groups were using or planning to use the income stream in a number of different ways. In this chapter the different uses identified from the interviews have been updated with information taken from the community groups' websites and refined to ensure consistent treatment across different groups. Table 7-1 shows the different categories of income use that community groups have been modelled as taken based on these information sources.

INDIRECT CARBON EMISSIONS RELATED TO INCOME USE

TABLE 7-1 HOW COMMUNITY GROUPS USE OR PLAN TO USE THE INCOME STREAM SHOWN BY THE SOURCE OF THE ASSUMPTION BLUE INDICATES THAT THE USE OF THE INCOME FOR THIS CATEGORY WAS DISCUSSED DURING THE INTERVIEW. GREEN INDICATES THAT CATEGORY COMES FROM THE GROUP'S WEBSITE. ORANGE INDICATES AN ASSUMPTION MADE ON THE PART OF THE RESEARCHER. THE BASES FOR THESE ASSUMPTIONS ARE DISCUSSED ALONGSIDE THE RESULTS OF EACH COMMUNITY GROUP

Group	Overheads	Loan	Shareholders	Employment	Energy generation	Energy efficiency	Other	Donated	Not received
Crucorney Energy Group	Blue		Blue	Blue	Blue			Blue	
Easton Community Centre									Blue
Green TEA						Blue			Blue
Hebden Bridge Town Hall	Orange						Orange		
Hexham river hydro	Blue		Green	Blue					Blue
Llangattock Green Valleys									Blue
Low Carbon Gordano	Blue		Green	Blue	Blue	Blue			
OVESCO	Orange		Blue	Blue					
Pennine Community Power	Orange		Blue		Blue	Blue		Orange	
Sheffield Renewables: hydro	Orange	Blue	Blue		Blue				
Sheffield Renewables: PV	Orange		Blue		Green	Blue			
Snitterfield Actioning Climate Change	Orange					Blue		Blue	
Talybont on Usk Energy	Blue				Blue		Blue		
Whalley River Hydro	Green		Green		Blue			Orange	
Total	11	1	8	4	7	5	2	4	4

7.1.1.1 Not received

Four of the groups do not receive the income stream from the project. In three of the cases this is because the projects were financed by an external organisation. Two projects were funded by another community energy group. One project was funded through a competition run by a commercial company. It was identified in Chapter 5 that groups in this situation do not know how the income stream is being used.

The fourth group is in a unique position. Although it has developed the project, it has done so in partnership with another local group with a distinct identity and aims. An agreement is planned between the two groups where the other group receives the income stream but agrees to give a

portion of this to the community group responsible for the project, to allow them to meet all their obligations. This model has been used previously in the community to run a community led cinema.

7.1.1.2 Overheads

A few groups drew attention to the fact that some of the income would be used to pay for overheads such as: insuring the system, maintenance contracts, site rent, project management, administration of share offers and decommissioning fees.

7.1.1.3 Loan

Bank loans were one source of finance for projects although only a few groups discussed their use during the interviews. One of the groups that discussed using a loan found that they did not need one. As well as paying back the original loan the groups will have to pay interest on the loan

7.1.1.4 Shareholders

Many groups raised finance through community share offers; individuals buy shares in the group and become shareholders. These shares do not change in value, i.e. a share worth £10 in 2010 is still worth £10 in 2011. Shareholders can withdraw their money by asking the group to payback the value of their shares. However most share offer documents state that money cannot be withdrawn before a certain year, to ensure that the group can continue to function. For this reason they also limit the amount of shares that can be redeemed each year, at the discretion of the directors. Some share offer documents state that the directors may redeem shares early if required.

In addition to paying back the original investment of the shareholders, the groups also pay interest each year on the remaining shares. The interest is simple interest, i.e. interest paid on the amount of shares left in each year. The interest rate that each group plan to give the shareholders varies between 3% and 7%. Some groups have linked the interest rate to the base interest rate. The sooner the group redeems the shares, the lower the amount of the income is spent on interest.

7.1.1.5 Employment

Job creation is one of the benefits attributed to community energy groups. A few groups were or were planning to use some of their income to employ a member of staff directly. The jobs created in this way were described as part time, paid minimal wages.

7.1.1.6 Energy generation

Some groups were planning to reinvest a portion of the income into additional community energy projects. This use was mentioned both directly and as part of what was described as a community benefit fund. However in both cases it was indicated that the group would be responsible for the development of these projects. The potential technologies the groups were considering installing or had installed using this income stream were: PV, hydro, ground source heat pumps and biodiesel production.

7.1.1.7 Energy efficiency

Some groups had or were planning to install energy efficiency measures either as part of a community benefit fund or directly. Groups that had already used the income for this purpose had installed cavity wall insulation, windows, doors and lighting.

7.1.1.8 Other

Two groups had used the income in a different way, where it was felt that they had direct control of the actions taken. These uses and assumptions are described in the section on the community group to which they relate.

7.1.1.9 Donations

Donations were made by some groups to a variety of other groups or individuals. Some groups donated money to a specific group, for example the management committee of the community building on which the project was based. Other groups were planning to use the income to fund a community benefit fund or series of activities over which they would have little control.

7.2 Methodology and assumptions

The income for each group has been calculated from the predicted energy generation modelled using the methods of energy generation described in Chapter 3. The feed-in tariff is affected by RPI. RPI is currently around 3% per year. Therefore RPI has been assumed to be consistent at 3% throughout all models. In reality this is unlikely, however it is not possible to predict with any level of certainty future RPI. RPI has been applied to all calculations unless otherwise stated.

In the model used in this work it is assumed that the group receive the total annual income in one lump sum, which arrives on the final day of the year. This is based on the start date of registration. It has been modelled that the income is used as soon as it is received, unless it was likely that the group would save up for something. Energy generation and efficiency measures have been modelled as if they are installed the day the income is spent. This was done to keep the model simple and will not have a major impact on results.

The priority order for payments was modelled as follows: Overheads, loan interest, loan repayment, shareholder interest, shareholder repayments. Where groups have made additional commitments these are assumed to be met next. Assuming that all these commitments can be met each year, the excess money is divided up between the other planned uses of the income in such a way that the group's cash flow in each future year remains positive up to the 25th year of receiving an income. Where there is a very high amount of uncertainty surrounding the use of income, no carbon modelling has been undertaken. This should not be interpreted as no impact, merely that any attempt to model a carbon impact would not reflect the project.

The system boundary described in Chapter 3 was implemented for this analysis. Only income that the community group had direct control over how it was spent was included within the system boundary. This was due to uncertainty about where the income went and how it was used. Therefore there is no attempt to model the carbon impact of income streams not received by the community group. This should not be interpreted as no impact, merely that any attempt to model a carbon impact would not reflect the project. The incomes that would be generated by the projects in this position have been calculated to illustrate the amount of money generated by an income stream.

This also has an impact on the modelling of income used for overheads, loans, shareholders, employment and donations. For these activities, only the part that relates to the community group has been modelled. To model the impact of income given to shareholders for example, a carbon cost has been assigned to the administration of distributing finances rather than the carbon cost of activities that the shareholder carries out. The carbon impact of these activities is presented in Table 7-2. The carbon impact was calculated using the EU27 input-output database.

Input-output databases assign environmental impacts per monetary unit to different industries based on the total amount of environmental impacts from a geographical area and the financial transactions within that region. The EU27 database is based on 27 countries within the EU and is calculated in terms of impact per euro spent in 2003. The average exchange rate in 2004 of 1.45

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euros to £1 has been used to convert this to £s. The figures calculated by this method should not be taken as definitive numbers, instead they represent that some carbon cost is present.

TABLE 7-2 CARBON IMPACT OF ADMINISTRATIVE TYPE TASKS

	Carbon impact kgCO ₂ eq/ £(2003)	NACE code ⁷
Overheads	0.41	74: Business services
Loan	0.28	65: Financial intermediation
Shareholders	0.28	65: Financial intermediation.
Employment	0.41	74: Business services
Donation	0.28	65: Financial intermediation

Overheads were not discussed by the majority of groups, however it has been assumed that most groups will have overheads. A figure of annual percentage spend on overheads was calculated based on the average spend of two groups. Low Carbon Gordano estimated they would spend approximately 10% of their annual income on overheads. Whalley River Hydro estimated 15%, not including rent (most groups pay no or nominal rent). Where the specific spend on overheads was unknown therefore a figure of 12.5% of annual income was used.

Loans and some share offers are linked to the base interest rate. Similarly to RPI, this has been modelled as a constant 0.5% based on current interest rates. Like RPI it is not possible to predict with any certainty how the interest rate will change in the future. Several groups indicated in the interviews that they intended to payback the shareholders capital as quickly as possible in order to minimise the amount that they had to pay in interest and maximise the amount available for “community benefit”. Therefore it has been assumed in each year that if there is sufficient capital available community groups pay back the total share offer divided by the number of years they estimated in their share offer document it would take them to pay back the share offer. I.e. if a group had raised a £100 share offer and estimated they would pay it all back over 10 years, each year they would pay off £10 of share capital. One group (Low Carbon Gordano) specified the amount they would leave available to pay off shareholders each year. This amount increased over time. Therefore in the model of this group, the amount of capital available in each year which is used to pay back shareholder capital is limited to the amount specified in their share offer document.

⁷ NACE codes is a European industry standard classification system to identify different industries and their activities. A list of NACE codes is available at http://ec.europa.eu/competition/mergers/cases/index/nace_all.html [accessed 2014]

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Employment has been calculated according to the salary the employee would receive, i.e. the cost to the group of other related requirements such as national insurance payments were not calculated. Interviewees frequently referred to low paid work. Therefore wages have been based on the minimum wage. This was £6.50 per hour in 2014 (GOV.UK, 2014b) or £52 per 8 hour day. This figure is not linked to RPI and has not been adjusted. The number of days of employment is varied for each group based on information given in the interviews.

Installing energy generation is modelled within the system boundary as it is a direct action of the group. To reduce the complexity of the model only PV is modelled. The carbon impacts assumed for PV are presented in Table 7-3. It has been assumed that the group are able to install the PV the day that they receive the income and this is when the carbon impact of the production of the system is accounted for. The carbon saving due to energy generation of this system is then accounted for on an annual basis for up to 25 years after the first year of generation. For the small scale PV projects modelled for most case studies in this work a cost of £2,000 per kW has been assumed based on current rates. For the larger PV installations which are assumed to be installed by Sheffield Renewables due to information available on their website it has been modelled that a 30kW system costs £42,000 and a 50kW system costs £70,000 with a linear scale between these points.

TABLE 7-3 CARBON IMPACT OF PV ENERGY GENERATION FIGURES FROM ECONINVENT DATABASE AND INTERVIEWS

Measure	Embodied carbon (kgCO ₂ e/£)	Annual carbon emissions (kgCO ₂ e/year £)	Lifetime (years)
PV (1kWp)	0.74	-0.19	25

Two groups planned to use the income to install a hydro project. Neither of these projects would generate sufficient capital for a hydro project within the time frame modelled. Therefore additional hydro projects were not modelled. However an estimation of the size of system they could install with the capital left over is given for both groups. This is based on current costs presented in Table 7-4 which was taken from Renewables First (2014). This was not adjusted for RPI.

TABLE 7-4 COST OF HYDRO PROJECTS

Installed capacity (kW)	Cost (£)	£/kW
5	100,000	20,000
25	190,000	7,500
50	330,000	6,500
100	560,000	5,600

Groups who were planning to install energy efficiency measures either as part of a community benefit fund or directly have a high degree of control over the actions. Therefore installation of these measures has been modelled within the system boundary.

Energy efficiency measures modelled in this work are: cavity wall insulation, loft insulation, boiler, window, door and LED lighting. Solid wall insulation has not been included as it is currently not commonly installed (Platt et al., 2011).

It has been assumed that energy efficiency measures are installed the same day that income is received by the group and that is when the carbon impact of their production is accounted for. Annual carbon savings due to the energy reductions are first accounted for a year after they are installed.

An equal number of each type of measure is installed. It has been assumed that each measure is installed on a different building as energy savings from multiple measures have been found to be non-additive which cannot be calculated using this model.

Table 7-5 shows the values used in the model that these assumptions generate. These values are valid for 2014. In the models they have been adjusted by grid carbon intensity and RPI for other years. Some measures have an average lifetime lower than the modelled time period. Therefore in the model a boiler only delivers energy savings for 10 years and a window for 20 years. The annual carbon emission reductions were calculated using the Thousand Flowers pathway carbon intensity for grid carbon combined with the average carbon reduction for each measure reported in the National Energy Efficiency Data Framework (NEED). The embodied carbon was calculated using EcolInvent 3.0.1 data based on the quantity of each measure that would be required for a 3 bedroomed detached house. The data behind this table are included in Appendix D.

TABLE 7-5 CARBON IMPACT OF INSTALLING ENERGY EFFICIENCY MEASURES CORRECT FOR 2014

Up to	Cost	Embodied carbon (kgCO ₂ e/£)	Annual carbon emissions (kgCO ₂ e/£ year)
10 years	4760	1.9	-0.33
20 years	4760	1.9	-0.24
25 years	4760	1.9	-0.18

To ensure consistency throughout the chapter the same graphs are presented for each community energy project, therefore the legend contains the same information whether or not a project uses the income stream for a particular activity. Prod stands for production, i.e. energy gen (prod) indicates carbon produced as a result of spending on energy generation. Similarly red stands for reduction; carbon reduced as a result of spending.

7.3 Community groups

In the following section the results of the model created to calculate the income of each community group, how they spend this income and the carbon footprint of this are presented. The specific assumptions that have been made for each group are included within the discussion and a justification for them made if not made in the sections above. Where information is known, i.e. how much income the group received in a particular year, this has been compared against the value predicted by the model to give some level of validation.

7.3.1 Crucorney Energy Group

Crucorney Energy group started planning their project around the time the feed-in tariff scheme was introduced in April 2010. The 9.8 kW PV project was installed on the village hall in March 2011, approximately one year later.

The group receive a guaranteed income for 25 years under the feed-in tariff scheme. The Generation tariff rate they received in their first year was 45.4p and the export rate, 3.2p. The project has an installed capacity of less than 30kWh and so they receive the export rate for 50% of the electricity they generate. Using the model of income generated under the feed-in tariff explained in section 7.2, the group receive an average yearly income of just under £5,000. The majority (97%) of this income comes from the Generation tariff rate, the remaining 3% from the export. Figure 7-1 shows the income stream and how this money is used.

During the interview it was stated that the group do pay for insurance on the PV system although the amount was not given. Therefore it has been assumed that 12.5% of their annual income is used to meet their overheads this equates to around £600 per annum.

The capital raised to complete the project was raised through two routes: grants and a community share offer. The community share offer raised £15,000. The shares are to be paid off over an eight year period, starting from the first year that an income stream is received. Shareholders will be paid an interest rate of 4% plus base rate. In total around £18,000 is paid to shareholders, including the return of their original investment.

For the first eight years of the income stream, the group donates half of the income remaining after overheads and shareholders have been paid, to the village hall management committee. In the interview this amount was estimated to be around £400 for the first year. This is approximately the amount that the modelled income predicts.

The remaining income is currently kept in a bank to ensure that the group can meet their commitments. The group were not sure what they would do with the income after eight years although three possible uses were suggested: provide employment, donate it all to another organisation or install a hydro scheme.

The group were considering employing someone to help them create charcoal. The group currently produces a small amount of charcoal but feel that this could be increased if they employ someone to do these tasks regularly rather than the non-regular tasks done by volunteers. This work would

be part time, around one day every two weeks. The group felt this would be for a small fee, here it has been assumed that the minimum hourly wage would be paid. This proposal was fairly well thought out and the group were already carrying out the activity to which it relates and therefore it was assumed that this would happen. Providing employment has been modelled to start during the 9th year as this is the first year the reserves would support continuous employment.

The group felt that it was possible that they would not exist in their current format or would have no use for the income after eight years and so the income might be donated to either the village hall or the local council after this time. However they may also use the income for a hydro project.

After 24 years receiving an income stream the group would have built up a surplus of around £55,000. At the current rates for installing hydro schemes, this would allow them to install a 3kW system.

The income stream modelled here results in the emission of around 17,000 kgCO₂eq. None of the uses of the income stream directly reduce carbon emissions. Figure 7-2 shows the carbon footprint due to use of the income stream. For the first eight years the carbon emissions are due to spending on overheads, shareholders and donations. During this time the annual carbon emissions reduce slightly as the reduction made in payments to shareholders is not matched by an increase in donations. For the remaining years, the carbon emissions are due to overheads and employment. During this time, annual carbon emissions are fairly constant.

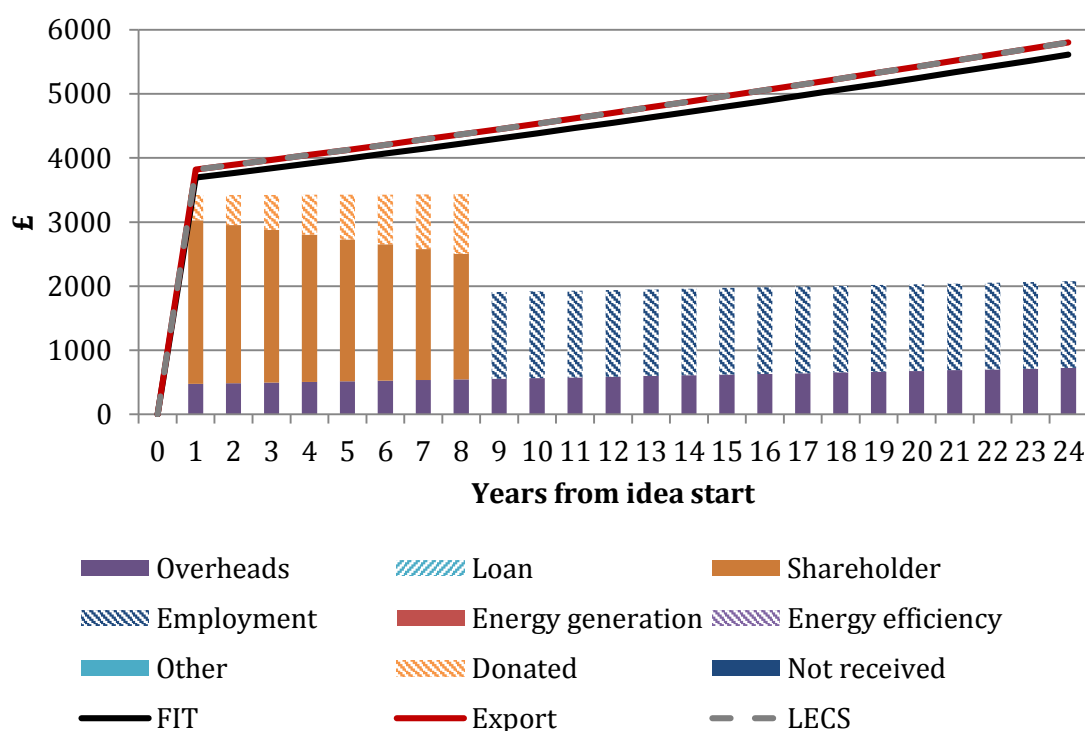


FIGURE 7-1 INCOME AND SPENDING OF CRUCORNEY ENERGY GROUP

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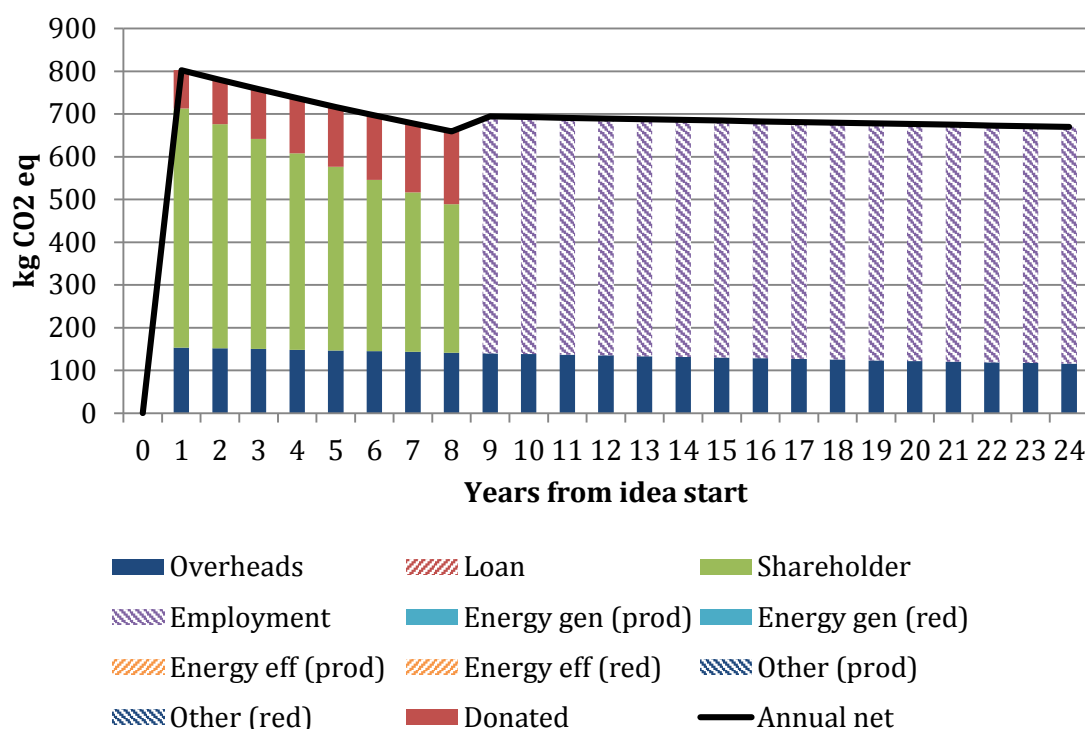


FIGURE 7-2 CARBON FOOTPRINT DUE TO INCOME USE OF CRUCORNEY ENERGY GROUP

7.3.2 Easton Community Centre

The project on Easton Community Centre was financed and organised by another community group, Bristol Energy Cooperative. This group raised the finance for two other community buildings, but were also able to fund a third, Easton Community Centre. The time lag therefore between the project idea and the installation of the panels is less than a month.

The 18kW PV project was installed in July 2012. It therefore receives the feed-in tariff for 25 years, with a Generation tariff rate of 15.2p and an export rate of 3.2p. The export rate is received for 50% of the electricity generated. An annual average income of £3,200 is generated by the installation, 90% of this comes from the Generation tariff rate, the remaining 10% coming from the export rate. Figure 7-3 shows the income generated by the project for each year from the beginning of the project idea.

Easton Community Centre does not receive any of this income; it goes straight to the Bristol Energy Cooperative. Within the defined system boundaries, the carbon footprint of Easton Community Centre's use of the income stream therefore was not modelled.

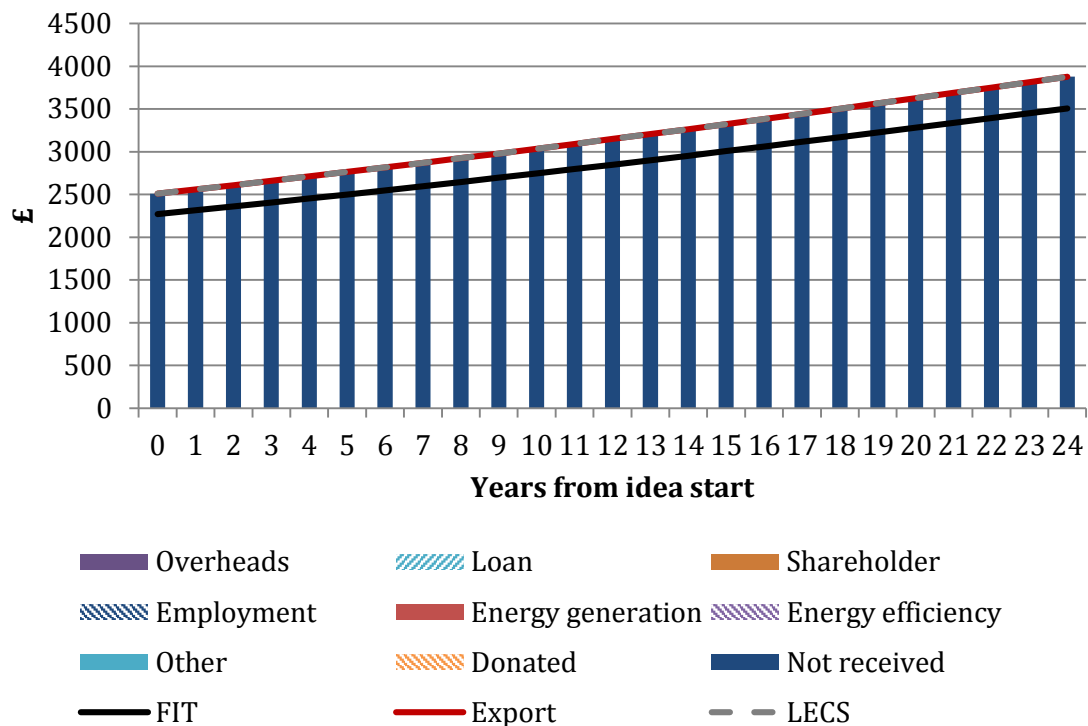


FIGURE 7-3 INCOME AND SPENDING OF EASTON COMMUNITY CENTRE

7.3.3 Green TEA

Green TEA started designing the project around the time the feed-in tariff was introduced in October 2010. The installation of their first system was completed 18 months later in March 2012. Their second system was installed a few months later in July 2012.

Both systems are guaranteed 25 years of income under the feed-in tariff scheme and a base export rate of 3.2p which applies to 50% of electricity generated. The 4kW system receives a Generation tariff rate of 45.4p and the 12.65kW system a Generation tariff rate of 15.2p. Together the systems generate on average £4,000, 93% of this comes from the Generation tariff rate and 7% from the export rate. The 4kW system produces about 47% of the income, with 53% of the income due to the 12.65kW system. The income and spending breakdown of Green TEA is shown in Figure 7-4.

The projects were financed by a different community group who also meet the overheads. During the interview it was suggested that the other community group will keep the feed-in tariff until the original outlay is recovered and then the income will be split between this community group and Green TEA. However the website of the other community group suggests that the entire income from the larger installation goes to the building that it is installed on. Therefore it has been assumed that the income from the larger installation is not received by Green TEA. The first £8,000 raised by the smaller installation is not received by Green TEA; the approximate cost of a 4kW PV system in June 2012, which is taken by the community group that financed the project. Half of the remaining income generated by this system is then given to Green TEA. In the interview it was proposed that any income would be used as match funding to install energy efficiency measures in community buildings. This has been modelled as the energy efficiency that could be installed from double the

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income stream. Over the time period modelled, this equates to around £36,000 of energy efficiency measures.

Due to the way the income is distributed the first revenue received and spent on energy efficiency measures happens six years after the project was conceived. The carbon footprint of these measures is shown in Figure 7-4. The amount available for energy efficiency measures remains about constant each year over the time period modelled and therefore the amount of carbon emitted annually due to the production and installation of energy efficiency measures also remains constant. Initially the carbon reduction due to the resultant energy reduction is smaller than the carbon emissions due to installation and so the annual net carbon emission is positive. However the reduction in carbon emissions due to the energy reduction builds over time as more measures are installed and their carbon cost paid back. This has the effect of reducing the annual net carbon emissions from year 9 onwards, which become negative from year 11 onwards. The use of the income stream by Green TEA over the time period modelled results in a reduction of 42,000 kgCO₂eq.

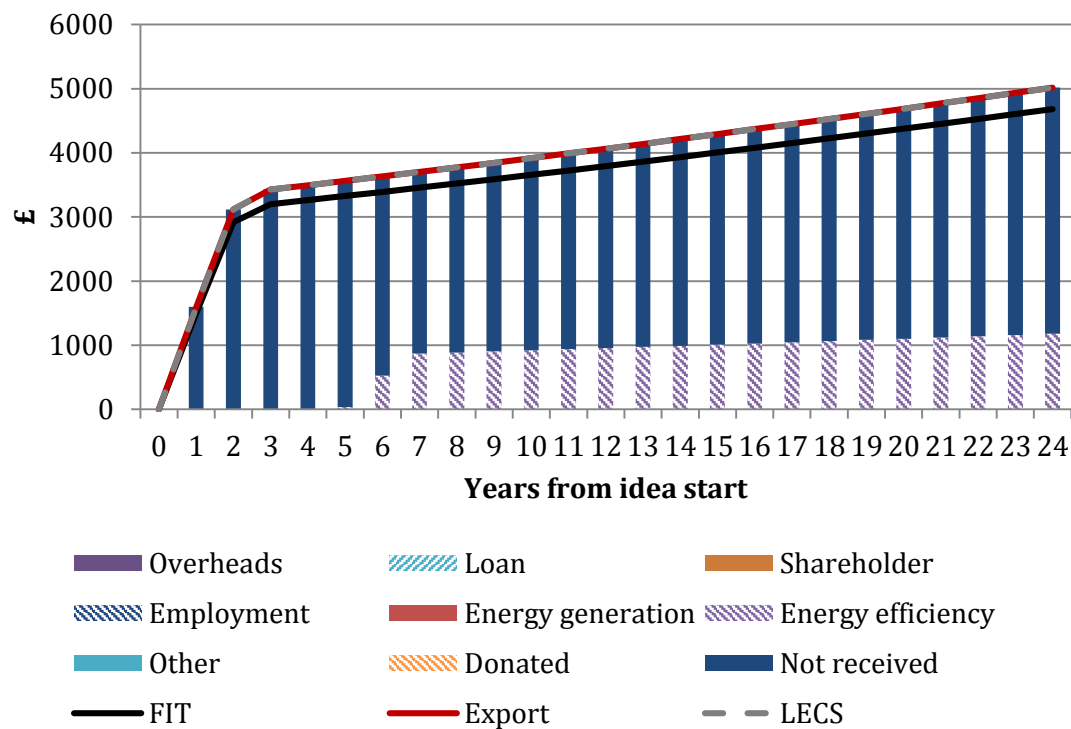


FIGURE 7-4 INCOME AND SPENDING OF GREEN TEA

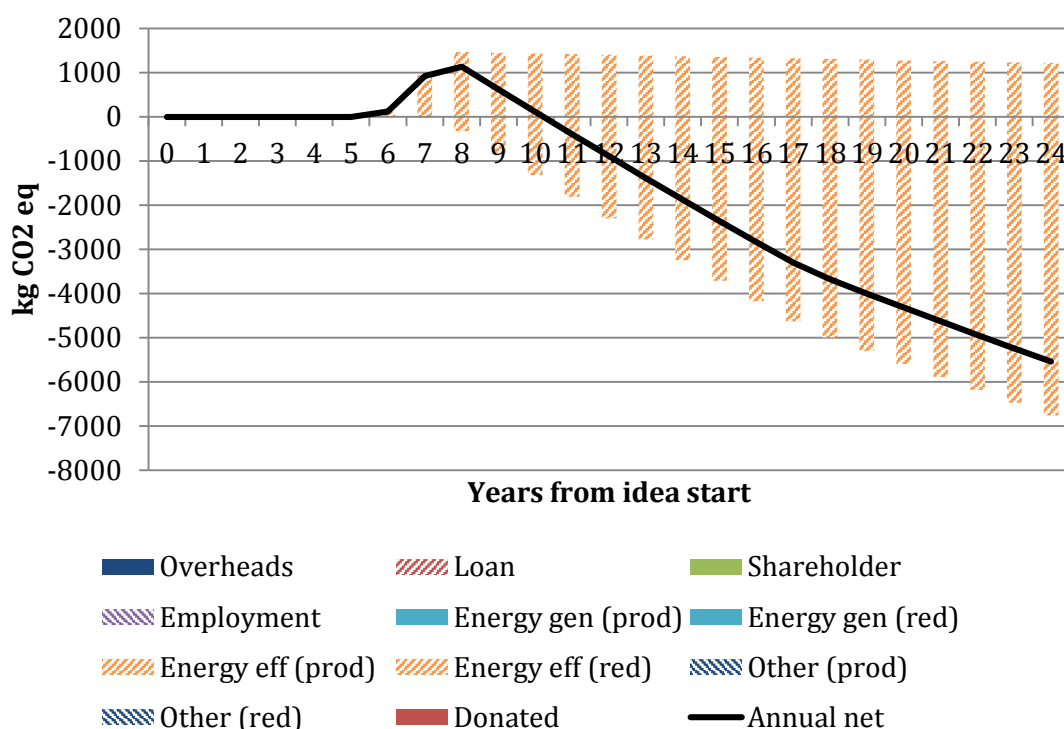


FIGURE 7-5 CARBON FOOTPRINT DUE TO INCOME USE OF GREEN TEA

7.3.4 Hebden Bridge Community Association

Hebden Bridge Community Association took over the Town Hall through community asset transfer in 2010 and according to the interview was committed to producing green energy from an early stage.

The 4kW PV system is guaranteed an income under the feed-in tariff scheme for 25 years and receives a Generation tariff rate of 21p. The export rate is 3.2p for 50% of the electricity generated. Over the time period modelled the system generates an income of £21,000. For the time period the income is received an average of £930 per year is generated. The majority (93%) is from the Generation tariff rate, the remaining 7% from the export. This is shown in Figure 7-6.

The system was financed as part of a much larger building project. During the interview the group were not sure if they would financially benefit from the income stream due to the cost of energy the building would need. Therefore it has been assumed that 12.5% of the income is used to cover overheads and that the remaining amount is used to pay for energy.

The prices for energy were taken from the Energy Saving Trust for 2013 then adjusted by RPI. It was assumed that bills were split 80% on gas and 20% on electricity. The carbon impact of gas use was calculated using Ecoinvent 3.0.1. The carbon impact of electricity use was based on the transition pathways work.

The carbon emissions due to the overheads are small in comparison to that due to energy consumption as shown in Figure 7-7. Community buildings are typically under heated because the management cannot afford to heat them to a comfortable level. Therefore it has been assumed

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that if the income was not available from this source, the building would not have been heated to this level. Over the life time modelled 66,000 kgCO₂eq of carbon are emitted.

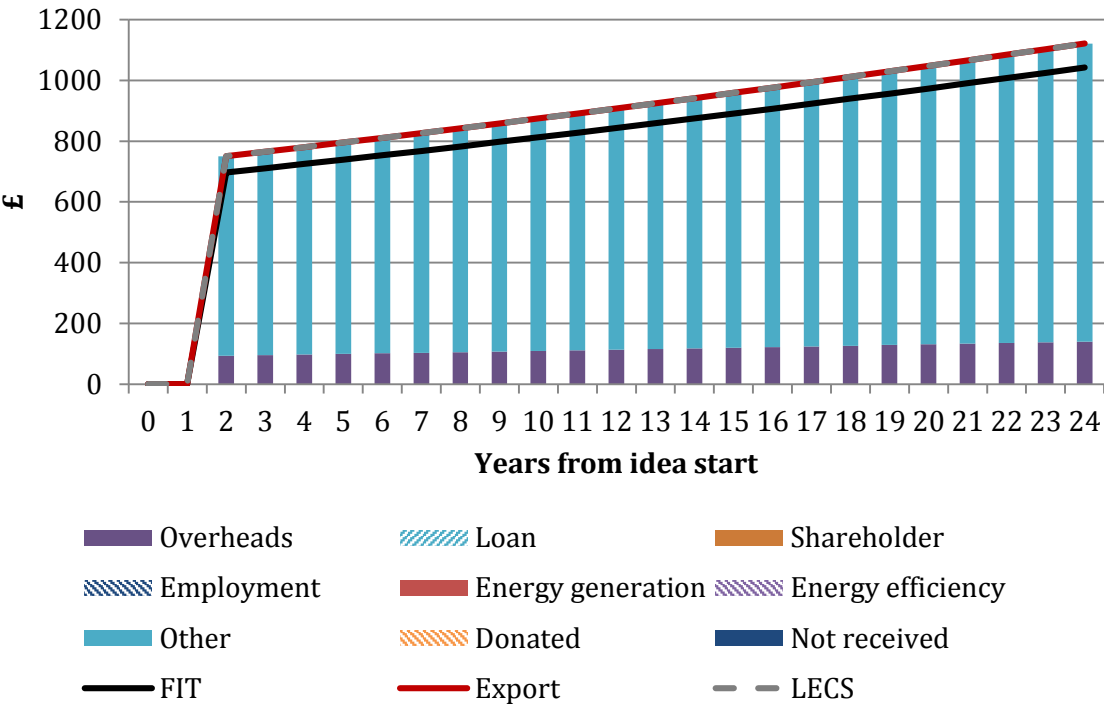


FIGURE 7-6 INCOME AND SPENDING OF HEBDEN BRIDGE COMMUNITY ASSOCIATION

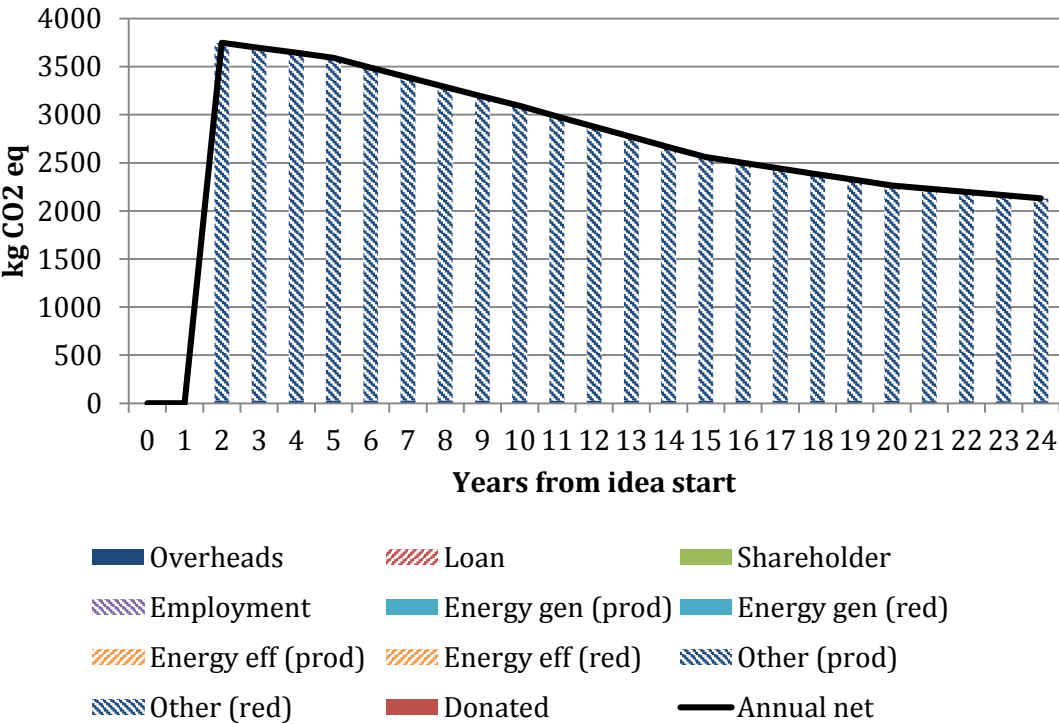


FIGURE 7-7 CARBON FOOTPRINT DUE TO INCOME USE OF HEBDEN BRIDGE COMMUNITY ASSOCIATION

7.3.5 Hexham River Hydro

Hexham River Hydro formed in 2010 to develop a hydro project on the local river. The project was abandoned three years later, when costs estimated by the detailed design report were substantially higher than those planned for. The Hexham River Hydro group felt that the risks involved with the project were too high for a community group.

The project has been modelled in this work as if the installation was completed in January 2015 according to the detailed design plans, i.e. higher costs modelled. The detailed design estimated that 602MW of energy would be produced annually, assuming a 2% downtime. If installed in 2015, the project would be guaranteed an income under the feed-in tariff scheme for 20 years with a Generation tariff rate of 17.75p. The scheme would have been grid connected and exported 100% of electricity to the grid. The group were planning to sell the electricity for slightly higher rate than the export tariff – 5p in 2012. This export rate has been adjusted for RPI in the same manner as the export tariff rate. The scheme would have had an installed capacity of 100kW, this is over the 50kW at which point the scheme could have been registered to receive renewable LECs. It has been assumed that these certificates would be sold for the same amount that OVESCO had agreed – 0.38p in 2011 and then adjusted with RPI. The project would generate around £190,000 of income on average per year for the first 20 years of the income stream. The Generation tariff rate accounts for 75% of this, the export 23% and the LECs 2%. This is around £4000 higher than the income predicted by the detailed design to be generated in the first year of operation. The breakdown of income and spending is shown in Figure 7-8.

It has been assumed that 12.5% of annual income will be spent on overheads. During the interview one of the planned uses of the income stream was planned to be creation of a part time, minimal wage job. The detailed design study allocated £4,800 to employment each year, this figure has been used in the model.

The project would have been funded by a share offer to raise £2.1 million. Shares were assumed to be paid off over 20 years, starting after the third year of income. The group were planning to pay around 4% interest on the investment, starting from the third year of income. It has been modelled like this because most groups in the sample with large share offers have a delay between receiving income and starting to pay off shares and provide interest. Over the time period modelled a total of £2.7 million is returned to investors.

It was planned that Hexham River Hydro would be formed into a community interest company, responsible for the running of the project. The income, less that required by the CIC to meet their obligations, however would go to the Hexham Partnership to support their work. The group therefore do not receive a portion of the income. This has been modelled as the maximum amount that could not be received and still meet all obligations in each year up to 25 years after the start of the income stream, with a positive cash flow. The combination of paying interest and paying off shares creates a pinch point in cash flow around the 12th year. Therefore up to this point, the amount of income not required by the group is small, around £2,000 a year. However after this point, the amount of income not required rises substantially, allowing the group to not receive around £20,000 per year.

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Figure 7-9 shows the carbon impact of this income stream. None of the actions taken by the group are likely to reduce carbon emissions. Over the life time modelled, around 530,000 kgCO₂eq is emitted due to the income stream. The majority of this is caused by paying the shareholders due to the large amount of money this involves. This decreases over time as the amount paid to shareholders decreases.

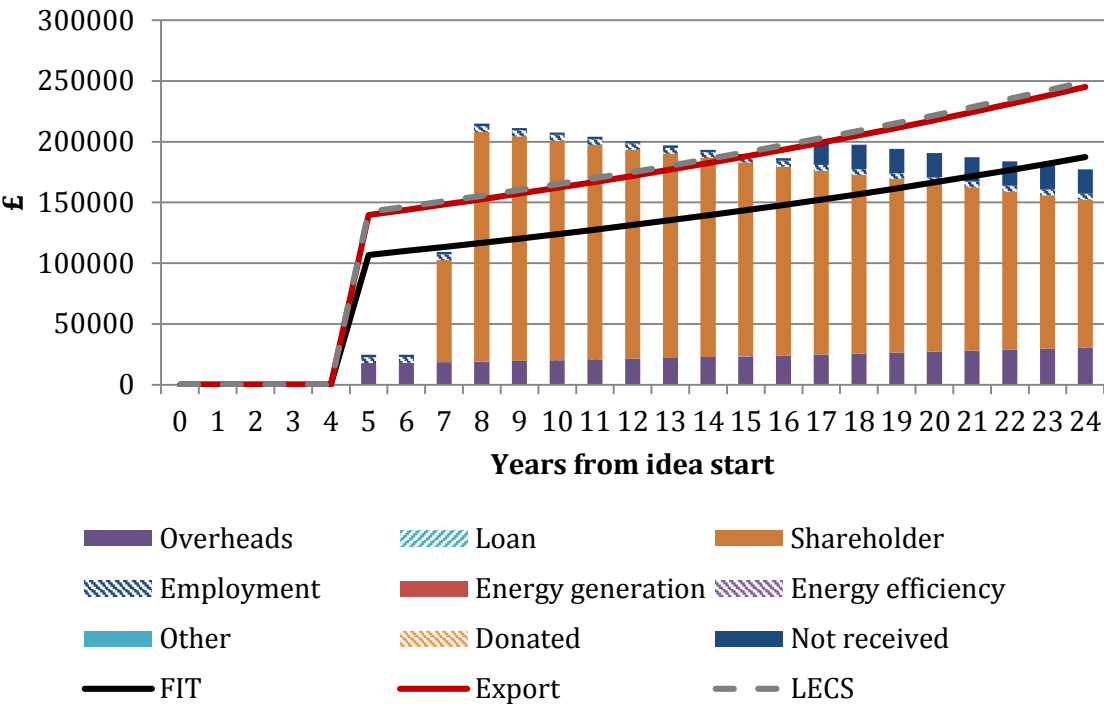


FIGURE 7-8 INCOME AND SPENDING OF HEXHAM RIVER HYDRO

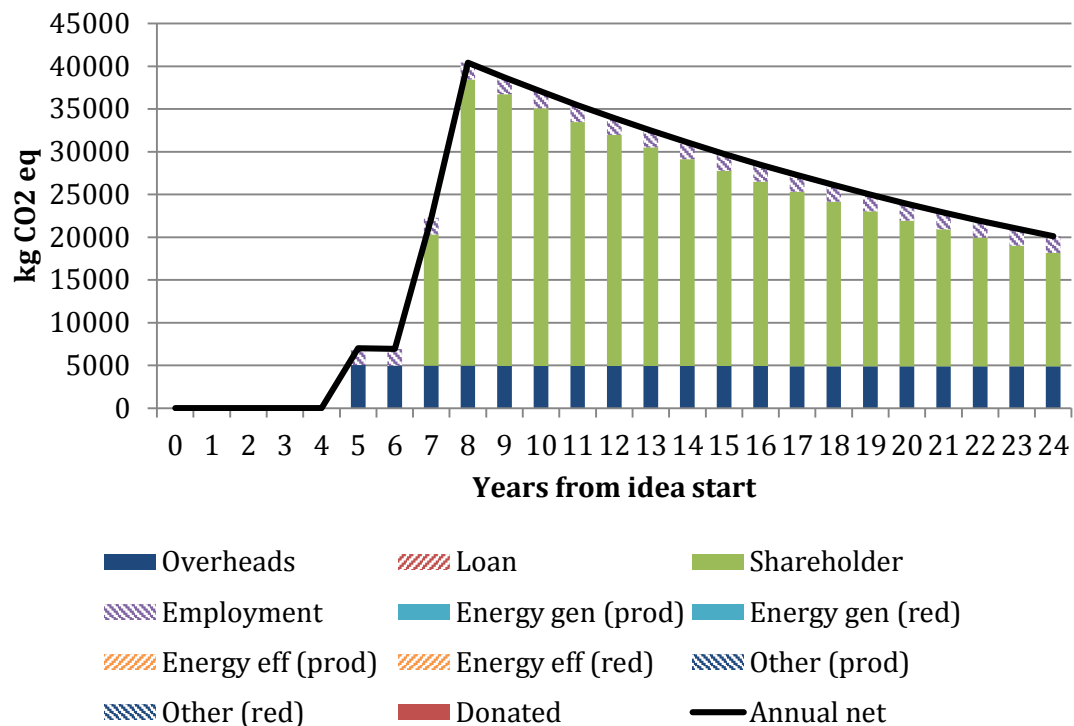


FIGURE 7-9 CARBON FOOTPRINT DUE TO INCOME USE OF HEXHAM RIVER HYDRO

7.3.6 Llangattock Green Valleys

The 4.23kW PV project was installed by British Gas as part of the British Gas Green Streets: Community competition. The regional heats for this took place in autumn 2009 and it has been assumed that this is around the same time the idea was started. The project was installed around 16 months later at the beginning of 2011.

The system is guaranteed an income under the feed-in tariff scheme for 25 years, with a Generation tariff rate of 37.8p. The export rate is 3.2p and applies to 50% of electricity generation. In the time frame modelled, the total income is around £40,000. The Generation tariff rate accounts for 96% of this income and the export rate 4%. Figure 7-10 shows the income generated by the project.

The interviewee did not know where the income went, but felt it was unlikely to come to the community group. Therefore it has been modelled as if the group do not receive this income. Therefore the carbon footprint of Llangattock Green Valleys' use of the income stream was not modelled.

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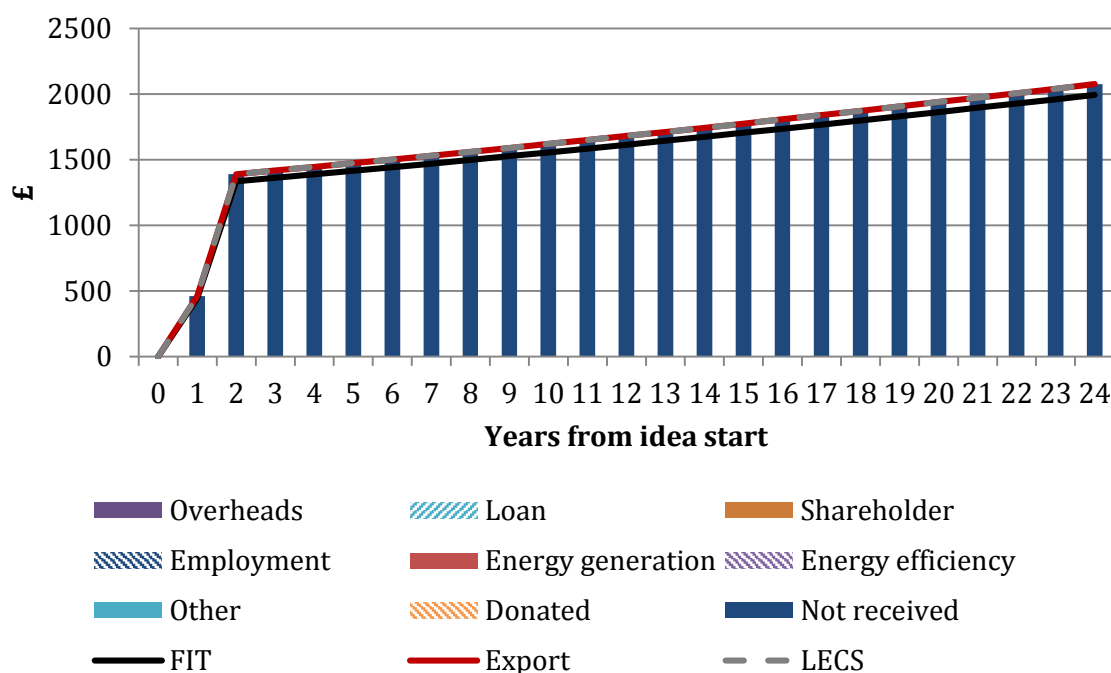


FIGURE 7-10 INCOME AND SPENDING OF LLANGATTOCK GREEN VALLEYS

7.3.7 Low Carbon Gordano

Low Carbon Gordano were in the process of installing an 1875kW PV system in December 2014. It has been assumed that generation will start in January 2015.

The 1875kW PV system is guaranteed an income under the feed-in tariff for 20 years. The Generation tariff rate was fixed at 6.61p under an amendment to the feed-in tariff scheme. This amendment allows community groups and schools to pre-register schemes and be guaranteed the rate at the time of registration rather than completion. It has been modelled that Low Carbon Gordano would register the system for LECs and would receive an income based on that received by OVESCO. It has been modelled that the group will organise a higher export rate than that guaranteed under the feed-in tariff scheme due to information given during the interview. This rate was calculated as 5.8p to match the income per kWh predicted by the group in their share offer. This calculated rate is similar to the export rate agreed by Hexham River Hydro. These assumptions mean that the project generates around £230,000 of income per year. This closely agrees with the expected income for the first year in the share offer document. Around half (50%) of the income comes from the Generation tariff rate, 46% from the export rate and 4% from the LECs. After 20 years of FIT income, this source disappears, meaning that the income per year roughly halves. Income and spending by year is shown in Figure 7-11.

The overheads are calculated to be around 10% of the income each year on the basis of the share offer document. This is roughly around £5,000 per annum. Part of this goes to paying another community group to manage the scheme.

Funds for the project were raised in a community share offer for £2.2 million. Shareholders are estimated to receive 7% of their investment in interest from the 2nd year onwards. Shares may be

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withdrawn from the 4th year. The amount of revenue available to pay back shares each year is based on the share offer document, this amount increases overtime. The amount of income devoted to shareholders drops over time due to the reduction in interest that needs to be paid. The sudden increase after year 12 denotes the increase in revenue available to pay back shares. In the time period modelled, £4.2 million has been given to shareholders or 80% of the income. At the end of the time period modelled not all shares have been paid back.

In the interview it was identified that a community benefit fund would be set up to reduce carbon emissions in the community. Two possibilities were suggested, investing in energy generation or energy efficiency measures. The remaining income therefore has been split equally between these two actions. For the first 11 years this amount is small, around £5,000 for each of the actions. If the rate is increased above this then cash flow becomes negative around this year. After this point the amount that can be used for these actions increases dramatically, up to around £15,000 for each.

Figure 7-12 shows annual carbon emissions and savings due to the income stream. During the first 17 years the annual net carbon emissions are positive, largely due to emissions associated with management of shareholders. At this stage the carbon emissions reduced by energy efficiency and generation measures are small due to the small amount of money available to undertake these activities. From year 18, the annual net carbon emissions become negative due in part to a reduction in the amount of spending on shareholders and in part due to the increased effect of a larger community benefit fund. Low Carbon Gordano are responsible for the emission of around 310,000 kgCO₂eq due to their use of the income stream during the time period measured.

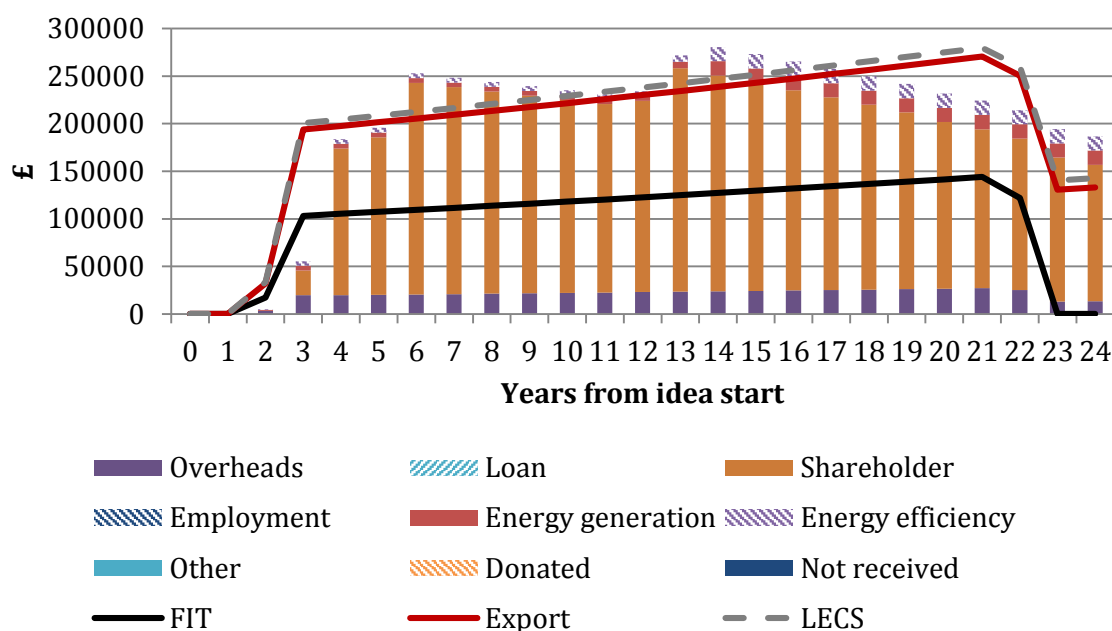


FIGURE 7-11 INCOME AND SPENDING OF LOW CARBON GORDANO

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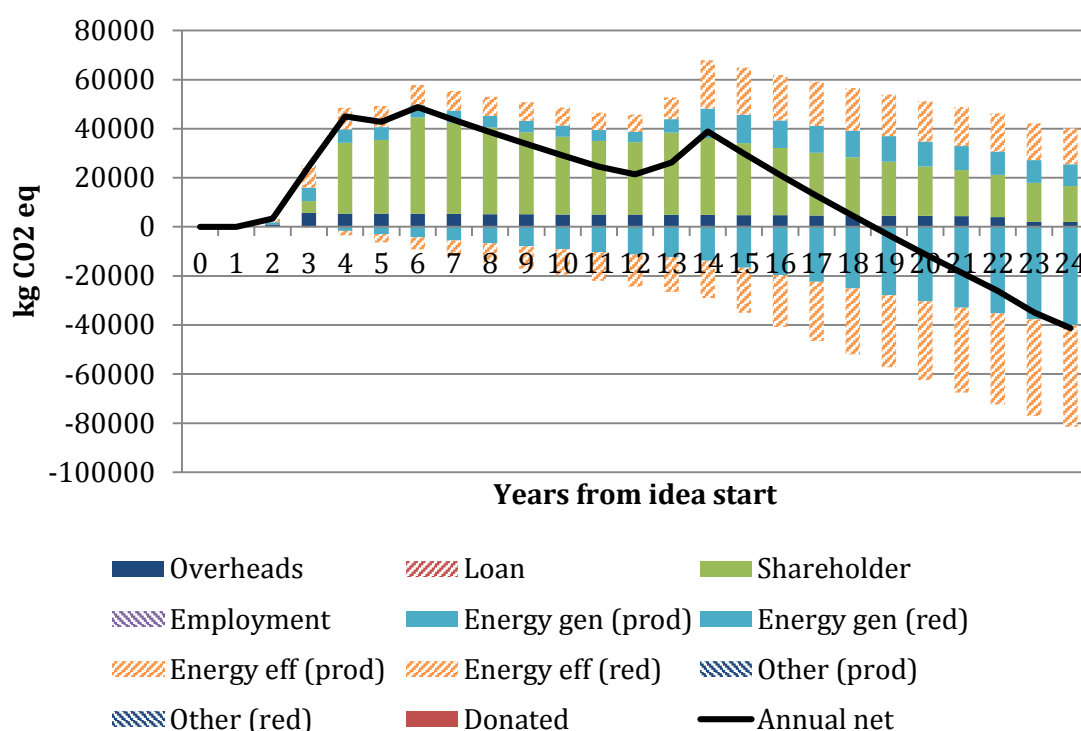


FIGURE 7-12 CARBON FOOTPRING DUE TO INCOME USE OF LOW CARBON GORDANO

7.3.8 OVESCO

The first system to be installed was in July 2011. During the interview it was stated that this had taken about a year. It was therefore assumed that the idea was conceived around July 2010.

The following three systems were installed between June and July 2012. All four systems are guaranteed 25 years of income under the feed-in tariff scheme. The rates each system receives are presented in Table 7-6. The export rate is the average rate the group have agreed with an energy supplier. The export of the 98kW system is the amount actually exported in the first year of operation. The rate received for the LECs is the rate they received in 2011, this has been adjusted for RPI. The majority of the income (76%) is received for the 98kW system, the 35kW system accounts for 12%, the 19.5kW system for 8% and the 9kW system 4%. According to the model OVESCO receive around £43,000 of income per year, this closely matches the £42,000 the schemes are predicted to earn by OVESCO. The Generation tariff rate accounts for 95% of this, the export around 4% and the LECs under 1%. Figure 7-13 shows the breakdown of income and spending.

TABLE 7-6 INCOME STREAM RATES FOR OVESCO SYSTEMS

Size (kW)	Generation tariff rate (p)	Export rate (p)	Export (%)	LECs (p)
98	32.9	4.5	20	0.38
35	15.2	4.5	50	N/A
19.5	15.2	4.5	50	N/A
9	16.8	4.5	50	N/A

Overheads of 12.5% have been assumed. This equates to around £6,000 per annum. The project was financed through a community share offer. This raised around £370,000, which was used to

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fund all four systems. Shareholders will receive around 4% interest on their investment per year, starting from the 3rd year of income. Shares will be paid back over a 20 year period, also starting from the 3rd year of income. Shareholders receive a total of just over £520,000 in the time modelled and all shares are paid off during this time.

The group currently provide part time employment for one person. It has been assumed that this is funded through the income stream, as the group's previous income stream had ended. It has been assumed that one person is paid minimum wage for 3 days a week.

The share offer documents states that a sum, not less than £500 will be donated to other community groups in the local area to aid them to reduce energy use. Therefore the model includes £500 per year donated to other groups.

In the interview it was suggested that the excess income would be used for additional energy generation projects in the area. Income that can be used for energy generation projects, without causing the cash flow to go negative at any point is first achieved around year 14. The excess income each year quickly increases after this point. It has been assumed that the group will carry out a large number of small PV installs as soon as they have the income. This is on the basis of their use of the first share offer. The income that could be spent on this action in the time modelled could be around £220,000.

For the majority of the time modelled the use of the income stream causes a net emission of carbon, shown by Figure 7-14. Initially this is because no actions are taken by the group that would cause a reduction of carbon emissions. Energy generation is installed in year 14. However a negative annual net carbon emission is not achieved until seven years later. This is because an increasing amount of PV is installed each year and each system takes approximately 4 years to payback the production carbon. Overall OVESCOs use of the income stream produces around 180,000 kgCO₂eq.

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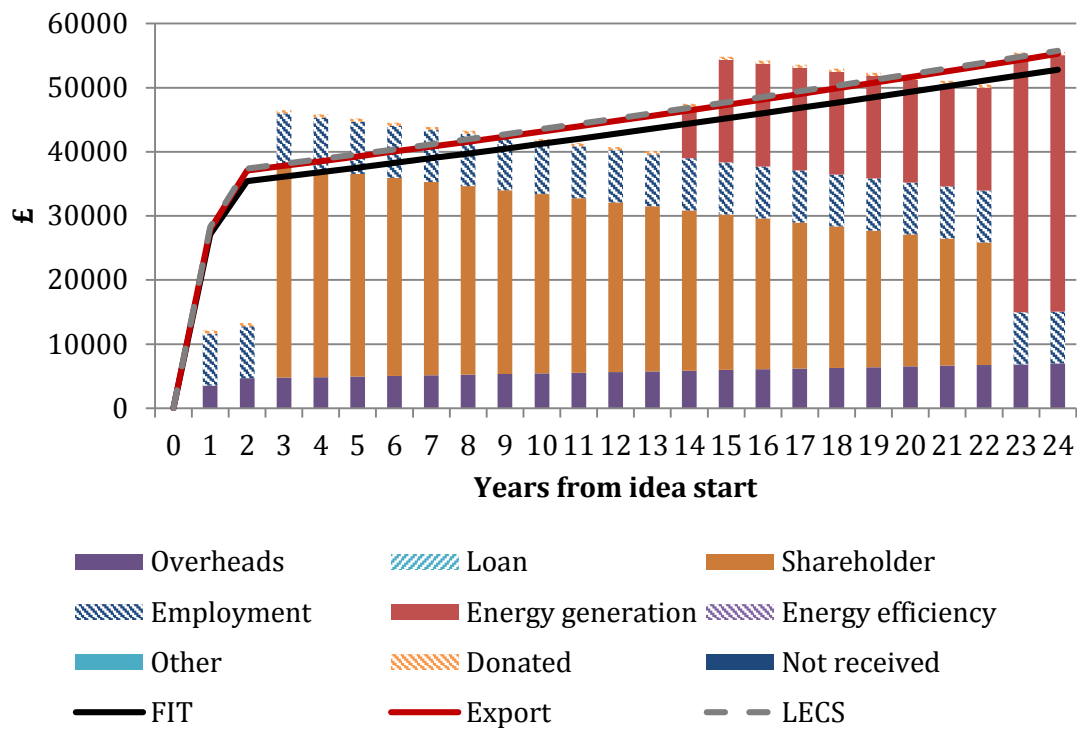


FIGURE 7-13 INCOME AND SPENDING OF OVESCO

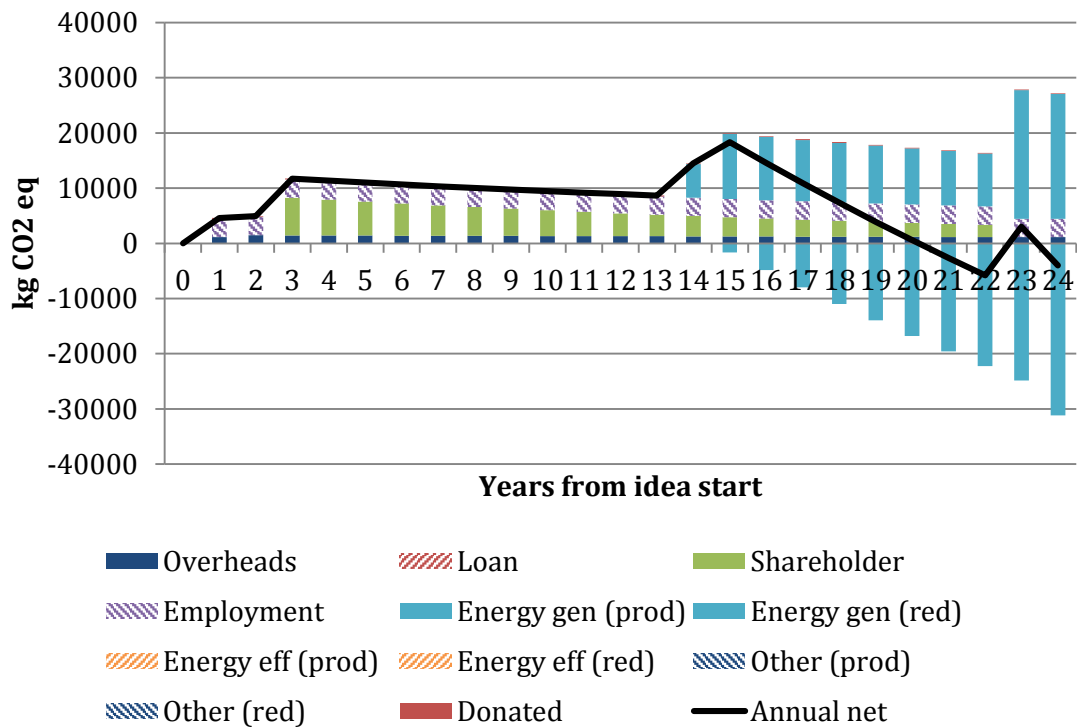


FIGURE 7-14 CARBON FOOTPRINT DUE TO INCOME USE OF OVESCO

7.3.9 Pennine Community Power

Pennine Community Power installed a 10kW wind turbine in October 2012. During the interview they stated that it had taken them about 6 months from the conception of the idea to completion of the installation.

The group are guaranteed an income of 20 years under the feed-in tariff scheme. When the system was installed the group received a Generation tariff rate of 28p and an export rate of 3.2p, assumed for 50% of generation. However the group had financed the project through a mix of a community share offer and grant funding. In early 2013, OFGEM stopped the feed-in tariff payments to the group as the grant funding was considered state aid and therefore not eligible under the scheme. The group were able to raise another share offer and payback the grant funding within a few months in order to become eligible for the feed-in tariff payments. This has been modelled as a gap of 3 months payments in 2013. It has been assumed that the rate they are receiving remained the same. The average annual income of the group over the first 20 years is around £10,000 based on an annual generation of 25,000 kWh estimated in the share offer document. After this time the average income is around £800. Around 94% of the income is from the Generation tariff rate, 6% is from the export rate. Figure 7-15 shows the breakdown of income received and how it is spent by the group.

It has been assumed that the overheads of the project are around 12.5%. This is around £1,000 a year. In total the project was funded by a share offer of £36,800, the first worth £28,000 and the second £8,800. Shareholders will receive around 4% interest on their investment, starting from the first year of income. Shareholders are not able to withdraw shares for the first 3 years, and the shares will be paid back over a 15 year period. In total shareholders will receive around £53,000 of the income or 27%.

The share offer states that the excess income will be used for subsidising energy saving schemes, educational projects, grant funding for environmental projects and investment in further community energy projects. It has been assumed that the group will undertake the energy saving and generation schemes and will donate funds to another local group who already undertake environmental and educational projects. The funds have been split equally among the four activities. It has been assumed that the group will install small PV systems as soon as they have the finance to do so on the basis that they discussed installing a small PV system on the local church during the interview.

The carbon impact of the income stream is shown in Figure 7-16. The carbon emissions associated with the overheads, shareholders and donations are relatively small as the amount of money allocated to these is low. Initially more carbon is emitted each year, due to installation of energy efficiency measures than is reduced by the energy savings these cause. In year 6 and 7, and again in 10 and 11, the net carbon effect is positive due to the carbon cost associated with producing PV systems. However from year 12 onwards the annual net carbon effect is negative. Pennine Community Powers use of their income stream leads to an overall carbon saving of 75,000 kgCO₂eq.

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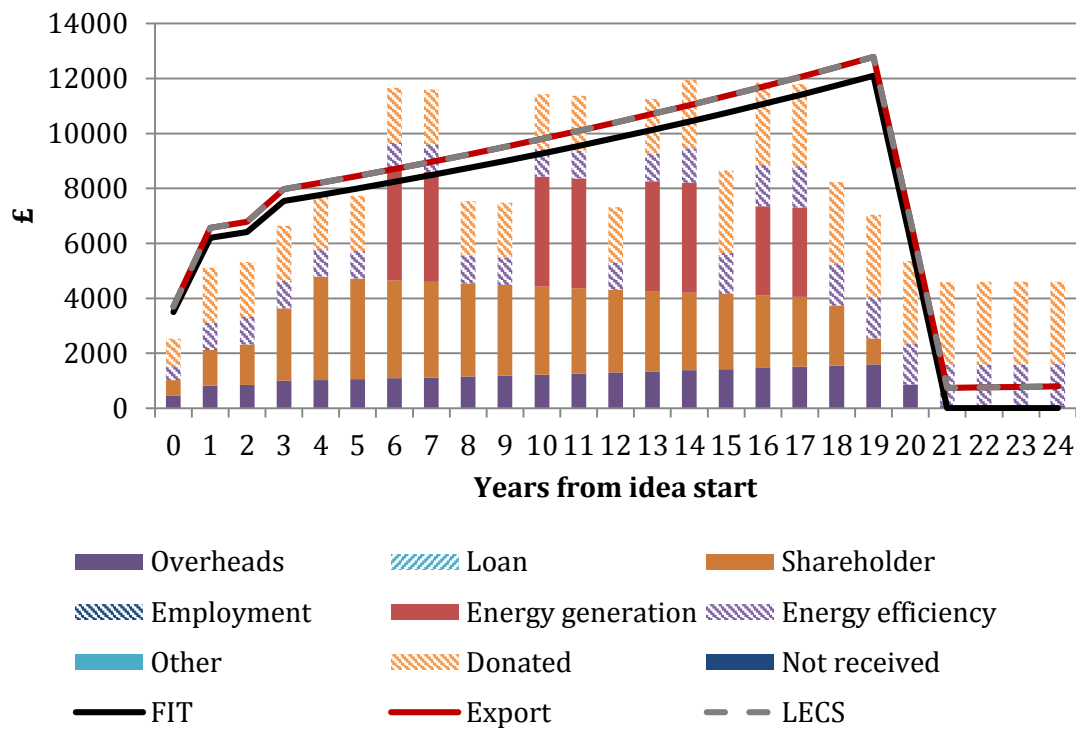


FIGURE 7-15 INCOME AND SPENDING OF PCP

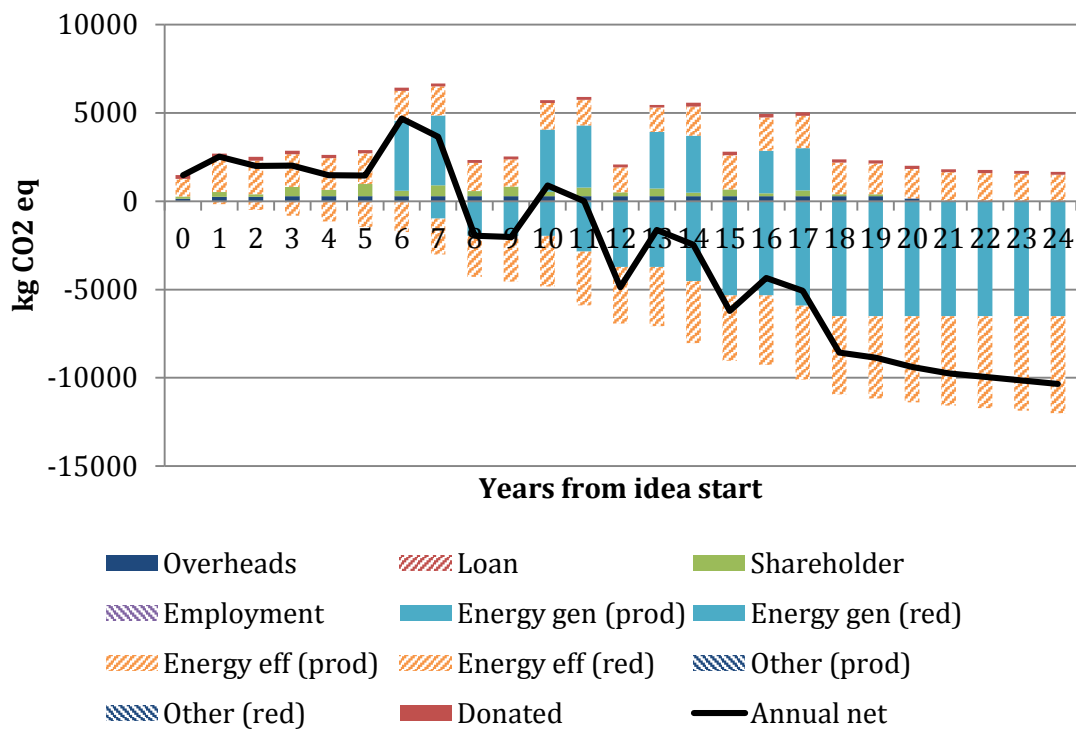


FIGURE 7-16 CARBON FOOTPRINT DUE TO INCOME USE OF PCP

7.3.10 Sheffield Renewables

Two separate projects have been modelled for Sheffield Renewables. The first is the hydro project which the group originally planned to do, for which the interview was carried out. The group halted this project when they were asked to install a second fish pass, increasing the cost. The second project that has been modelled is the PV system the group installed using the money they had raised for the hydro project, in order to start generating an income. This project is modelled on information available on the group's website along with information felt to be applicable gained from the interview.

7.3.10.1 Hydro

This project, an 80kW hydro scheme, has been modelled as if installation was completed in January 2015. The idea start date has been based on the first site visit of the group in November 2008.

The project was to install an 80kW scheme which would have an average annual generation of 310 MW according to the group's website. The scheme would be guaranteed 20 years of income under the feed-in tariff scheme. The Generation tariff rate would be 17.75p. It has been assumed that as 100% of the electricity is due to be exported, the group would have organised a higher export rate than that guaranteed by the scheme. It has been assumed that the export rate agreed is the same as that for Hexham River Hydro. It has been assumed that the group would receive LECs at the same rate as OVESCO. The project would receive an average income of £91,000 a year, 75% of this would come from the Generation tariff rate, 23% from the export and 2% from LECs. The breakdown of income and spending is shown in Figure 7-17.

The project was estimated to cost £850,000, higher than the £600,000 the group had raised through a mix of loans and community share offers. It has been assumed that this higher cost would be met through the same proportion of loans and shares. Therefore the project has been modelled as if it has a share offer of £350,000 and loans of £500,000. Sheffield renewables were aiming to pay investors 3% interest on their investment. This would have been paid from the 2nd year onwards and the shares are paid off over a 20 year period starting in the 3rd year. Shareholders receive around £380,000 during the time period modelled; this is around 22% of income. It has been assumed that the rate of interest due on the loan is 4%. It has been assumed that the loan is paid off at a steady rate over 20 years and that interest is due from the first year. A total of £660,000 has been paid towards the loan by the end of the time period modelled, or 38% of the income. It has been assumed that the overheads equate to around 12.5% of annual income. This is around £11,000 per annum.

During the interview it was stated that the excess would be reinvested in the next scheme. The group's main focus around the time of the interview was hydro projects. Therefore it has been assumed that the excess is spent on the next project. By the end of the time modelled in this work the excess amounts to around £470,000. On the basis of the cost of the 80kW scheme, this would allow them to install a project of about 40kW. This has not been modelled within the time frame however as they would be likely to wait until all income was received.

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Sheffield Renewables income use leads to a net carbon emission of 200,000 kgCO₂eq. Although the annual net carbon impact is positive, it does reduce overtime as shares and loans are paid off.

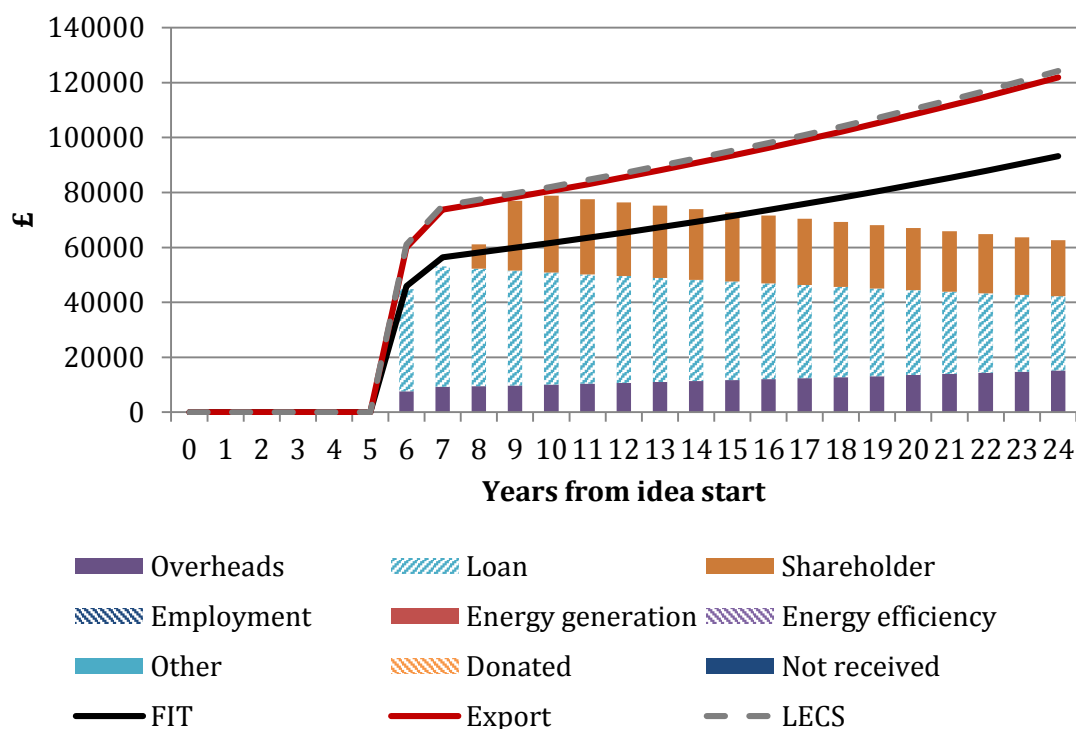


FIGURE 7-17 INCOME AND SPENDING OF SHEFFIELD RENEWABLES: HYDRO

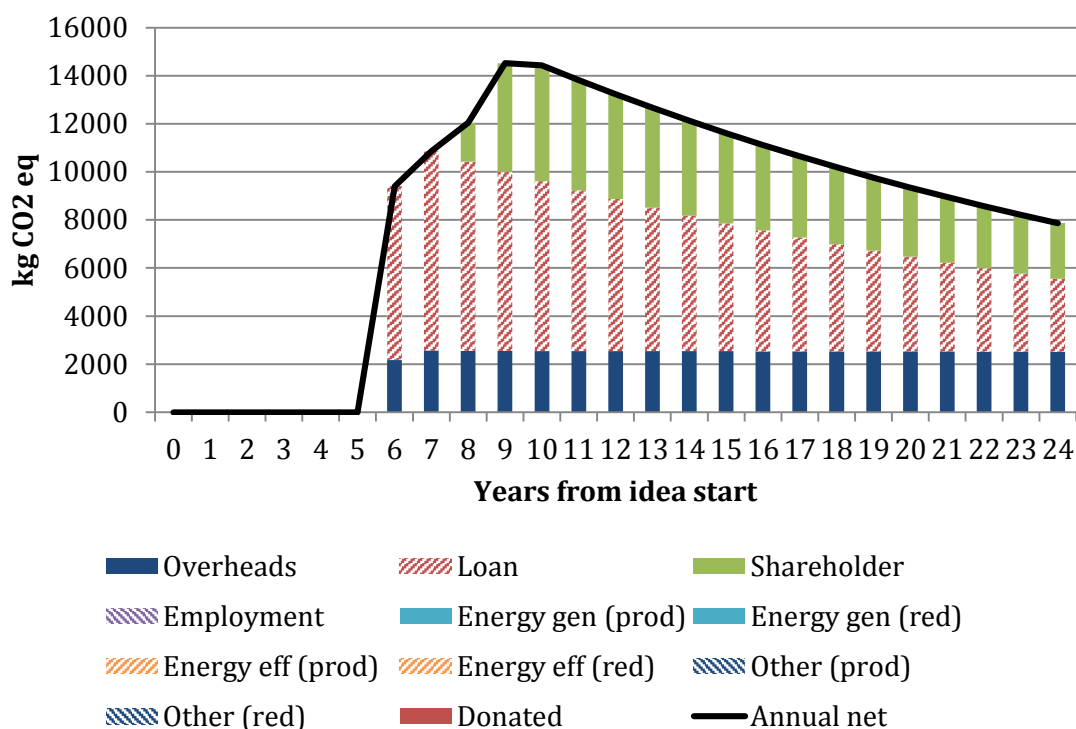


FIGURE 7-18 CARBON FOOTPRINT DUE TO INCOME USE OF SHEFFIELD RENEWABLES: HYDRO

7.3.10.2 PV

It has been modelled that the idea for a PV system was conceived around April 2013 on the basis of answers given during the interview that took place at this time. A 50kW PV system was installed on a community building 12 months later.

The project was preregistered with OFGEM in November 2013 and so is guaranteed an income under the feed-in tariff scheme for 20 years, with a Generation tariff rate of 12.9p. As the system is over 30kW, the amount of export is measured rather than being assumed to be 50%. It has been assumed that the export is 20% of generation, based on figures from OVESCO. The group receive an export rate of 4.5p. On the group's website it is indicated that the electricity is sold to the community building at below market rate. It has been assumed that the 80% of electricity not exported is sold to the building at 20p per kWh, to achieve an income of around £15,000 a year to match that reported on the website. It is not known if this rate is below market rate for non-domestic buildings. The project achieves an average income of £15,000 per annum. The Generation tariff rate accounts for around 43% of this, the export 3% and the sales to the community building 54%. Sheffield PV is the only project in the sample that raises income in this manner. The breakdown of income and spending is shown in Figure 7-19.

This project was funded using £60,000 of the share offer that was raised for the hydro project. Consequently the same assumptions have been made for the payback of the shares and the interest received. In total around £81,000 worth of payments are made to the shareholders, about 24% of the total income received. Overheads were assumed to be 12.5% of the annual income; this is around £2,000 per year.

In the interview it was suggested that income from PV projects would be used to install energy efficiency measures in the local area. The group's website suggests that the group are planning to install additional PV projects between 30 and 50 kW. Therefore it has been assumed that the income remaining after the groups obligations have been met, will be split approximately equally between energy efficiency measures and energy generation. An average of £5,000 a year is available for energy efficiency measures. During the life time modelled in this work, the group can afford to install two PV systems in their suggested range: one in year 10 and another in year 20. This is shown by the peaks in

Overall Sheffield Renewables use of the income stream results in a net reduction of around 210,000 kgCO₂eq as shown in Figure 7-20. The net annual carbon emissions are initially positive for the first 7 years due mostly to installation of energy efficiency measures. After the 7th year, the savings from energy reduction outweigh the new installations. In year 10 and 20 the carbon emissions due to the production of PV systems cause the net annual carbon emissions to become positive for that year. However the overall trend is negative.

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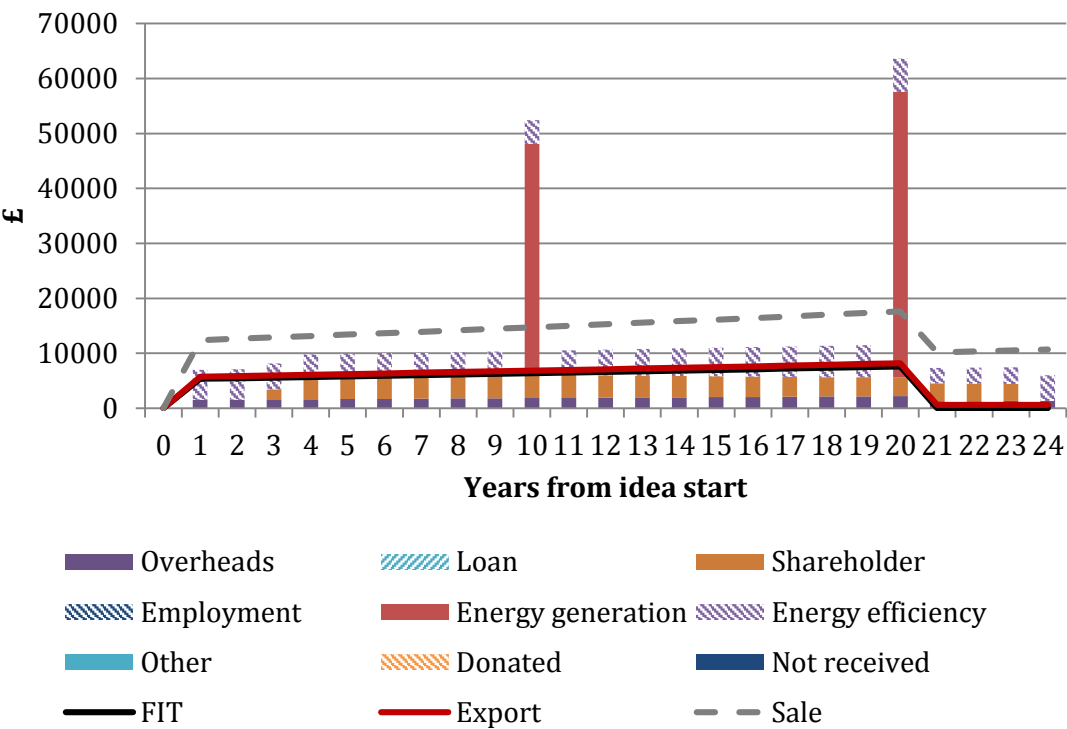


FIGURE 7-19 INCOME AND SPENDING OF SHEFFIELD RENEWABLES: PV

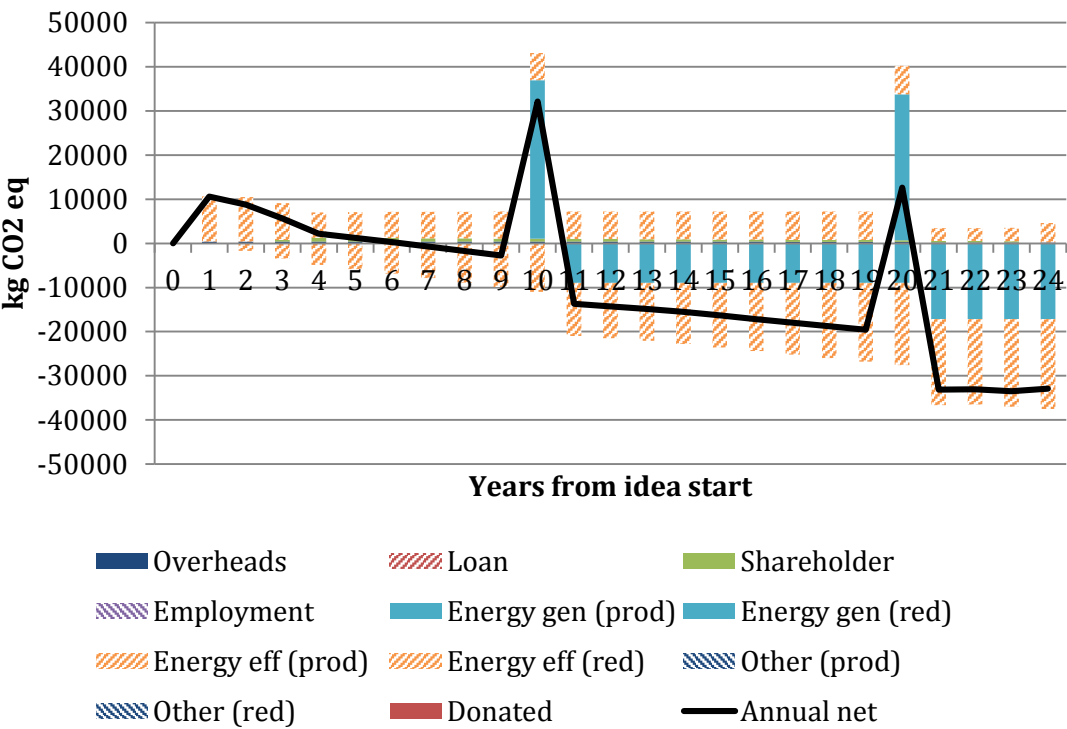


FIGURE 7-20 CARBON FOOTPRINT DUE TO INCOME USE OF SHEFFIELD RENEWABLES: PV

7.3.11 Snitterfield Actioning Climate Change

The first mention of the scheme modelled here on the group's website is in October 2010. This has been taken as the point at which the idea was conceived. The first two community installations took place around 14 months later in early December 2011 and the third in July 2012. All three systems are 3.6 kW.

All three systems are guaranteed an income for 25 years under the feed-in tariff scheme. The two schemes installed in December 2011 receive a Generation tariff rate of 45.4p and the one in July 2012 receives 21p. All systems receive an export rate of 3.2p for an assumed 50% of electricity generation. This amounts to an average annual income of around £5,000. The majority (96%) of this income comes from the Generation tariff rate, 4% comes from the export rate. The breakdown of income and spending is shown in Figure 7-21.

It has been assumed that the group spend 12.5% of their annual income on overheads. This is around £500 per year. The group donate the income from the system installed in July 2012 to the building that it is installed on. They also donated the first two years of income from one of the December 2011 systems to the building that it was installed on. In total the amount donated to other groups is around £24,000. The remaining money is used for a community fund to reduce carbon emissions. To date this fund has been used to install energy efficiency measures. It has therefore been assumed that this will be the only use of the community fund. The amount of funds available for the community fund predicted by this model closely matches those actually available to date. In the time modelled here around £74,000 will be made available for the community fund. This equates to 68% of the income.

Over the time frame modelled in this work, the use of income by this group results in a net reduction of carbon emissions of around 80,000 kgCO₂eq. The breakdown of this is shown in Figure 7-22. For the first 8 years the annual net carbon emissions are positive due to the carbon costs of installing new energy efficiency measures. After the 8th year the annual net carbon emissions are negative as the energy reductions each year are greater than carbon emissions due to new energy efficiency installations. The carbon impact of the income that is donated to other groups and the overheads is small in comparison to the energy efficiency measures.

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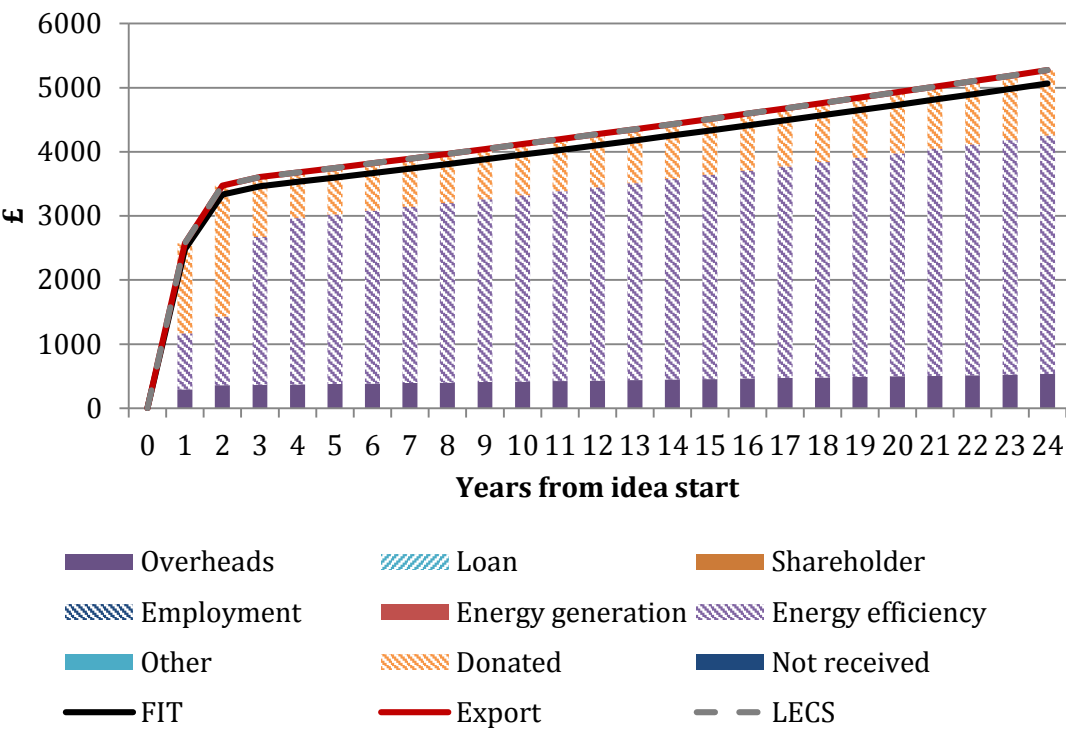


FIGURE 7-21 INCOME AND SPENDING OF SNITTERFIELD ACTIONING CLIMATE CHANGE

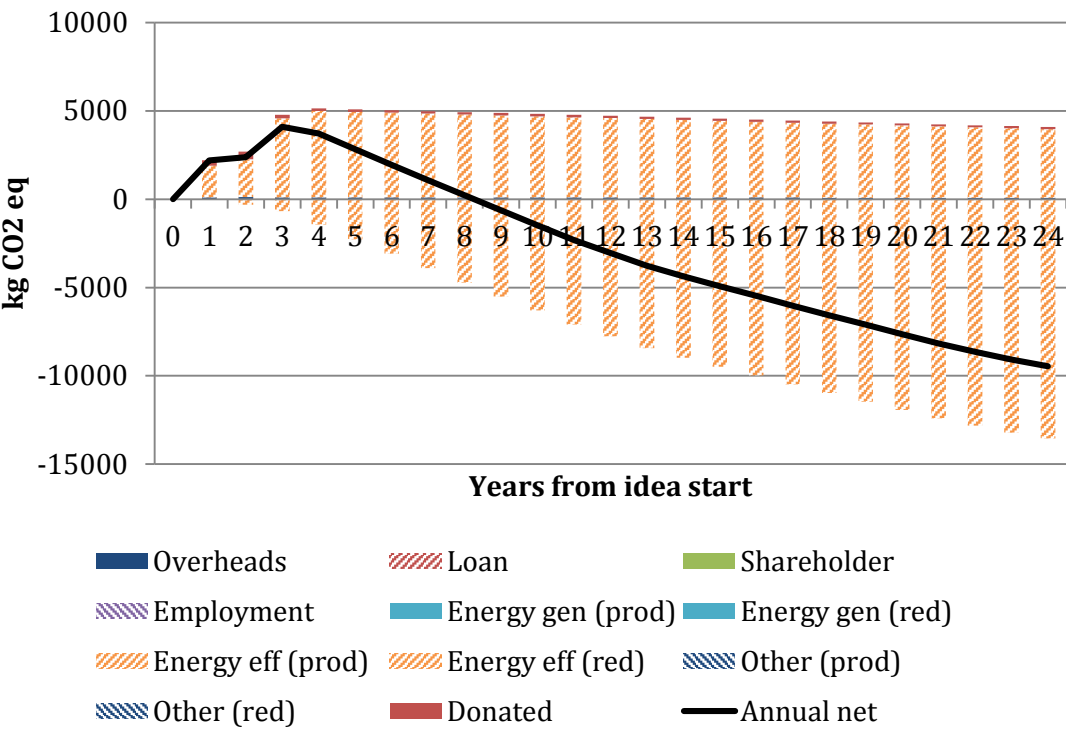


FIGURE 7-22 CARBON FOOTPRINT DUE TO INCOME USE OF SNITTERFIELD ACTIONING CLIMATE CHANGE

7.3.12 Talybont on Usk Energy

The hydro site of Talybont on Usk Energy was identified in February 2003 according to the group's website. It has been assumed that this was the start of the idea for the current scheme. The 36kW turbine was commissioned in November 2005. This was before the introduction of the feed-in tariff scheme. The group received an income under the Renewable Obligation Certificate scheme and by selling the electricity generated to an energy supplier from January 2006. When the feed-in tariff scheme was introduced in October 2010, the group did not qualify for either scheme as the turbine had been funded through grant funding. Other than electricity sales, no income was received between around October 2010 and October 2012, when a special exception was made for Talybont on Usk energy and a new category was added under the feed-in tariff scheme.

In 2009 the group reported an income of around £30,000. It has been assumed that this rate was received for each full year of generation prior to the introduction of the feed-in tariff. Post October 2012, the group receive a feed-in tariff of 9.4p. It has been assumed that this is guaranteed for 25 years. It has been assumed that the group receive an export rate of 3.2p for 100% of electricity generated. Under these assumptions it has been modelled that the group would initially receive around £30,000 a year which matches the amount estimated by the group on their website. The turbine is estimated to produce around 235,000 kWh per annum by the group - this figure is used in the model. In the time frame modelled the group receive a total of around £760,000. The income prior to the feed-in tariff scheme accounts for around 19% of this income. The Generation tariff rate accounts for 61% and the export rate 20%. The income and spending by year is shown in Figure 7-23.

Overheads were predicted to be around 25% of the annual income by the group during the interview. This is about £9,000 a year. In 2011, the group used the income to install a 4kW PV system on the local village hall. It has been assumed that this cost around £8,000. They also donated £5,000 to other local groups. In 2014 the group installed a second 4kW PV system on the village hall, alongside an air source heat pump. As no more information about the size of the heat pump is known, this has been modelled as a third 4kW PV system. The group have also donated an amount of money to the local community council. It has been assumed that this amount is £5,000.

The group also run a car club. This car club was initially funded by grant funding and consisted of an electric car and a biodiesel car. In 2013 an electric van was bought to replace the electric car which had broken. It has been assumed that this van was bought using the income from the hydro project. It has been assumed that the biodiesel car and electric van have a life time of 10 years and will be replaced like for like using the income. Table 7-7 shows the properties assumed for the cars. The costs were taken from the manufacturer's websites for a new version of the cars currently owned by the group. The weights and carbon emissions associated with the production of the vehicles were estimated using Ecoinvent 3.0.1.

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TABLE 7-7 PROPERTIES OF TALYBONT ON USK ENERGYS CAR CLUB VEHICLES

Vehicle	Weight (kg)	Cost (£)	Embodied carbon (kgCO ₂ eq)
Electric van	1200	14000	9000
Biodiesel car	1600	16000	12000

It has been assumed that these vehicles offset journeys that would otherwise have been made in a car with a petrol consumption of 0.074kg/km. It has been assumed, to avoid adding further uncertainty to the model, that both the biodiesel and electric vehicles have an emission of 0 kgCO₂eq/km. The electric van is usually charged at the village hall to make use of the electricity generated by the PV, which would result in emissions per km or around 0 kgCO₂eq. However the income model assumes that this electricity is offsetting grid electricity and is therefore already accounted for. Assuming 0 kgCO₂eq is therefore double accounting of the electricity. There is some debate surrounding the carbon emissions that should be attributed to biodiesel, the feedstock for the biodiesel is particularly important. The group use biodiesel created from used cooking oil. It should be recognised that the emissions per km associated with these vehicles could be higher than petrol. This will reduce the amount of carbon emissions reduced by the use of the income stream shown in this model. It is not known how the rest of the income is used by the group. Therefore no use has been assigned to it and the carbon impacts have not been modelled.

During the time period modelled and using the assumptions laid out above, the use of the income stream by Talybont on Usk Energy group results in an overall reduction in carbon emissions by around 14,000 kgCO₂eq. This is shown in Figure 7-24. Use of income in the first 12 years of this project cause an annual net increase in carbon emissions due to the overheads and the amount spent on installing PV and the car club. However after this time the energy generated by the systems is enough to cause an annual net carbon reduction. This annual net carbon reduction however is not enough to offset in one year the carbon emissions associated with buying a new vehicle.

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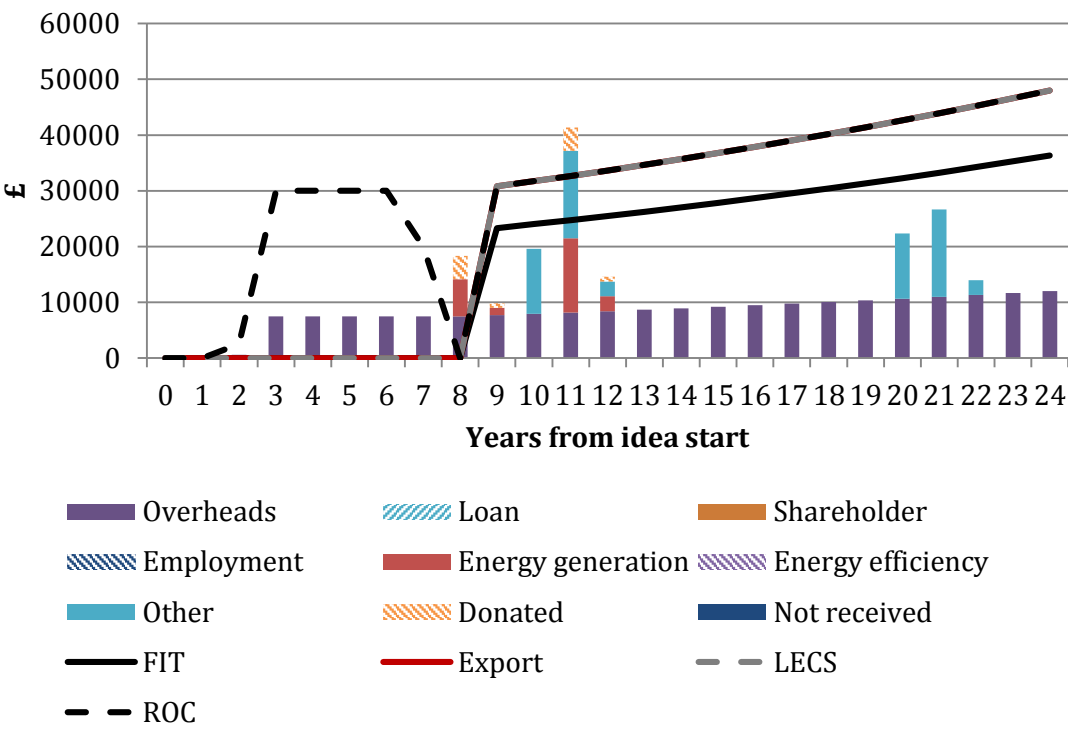


FIGURE 7-23 INCOME AND SPENDING OF TALYBONT ON UK ENERGY

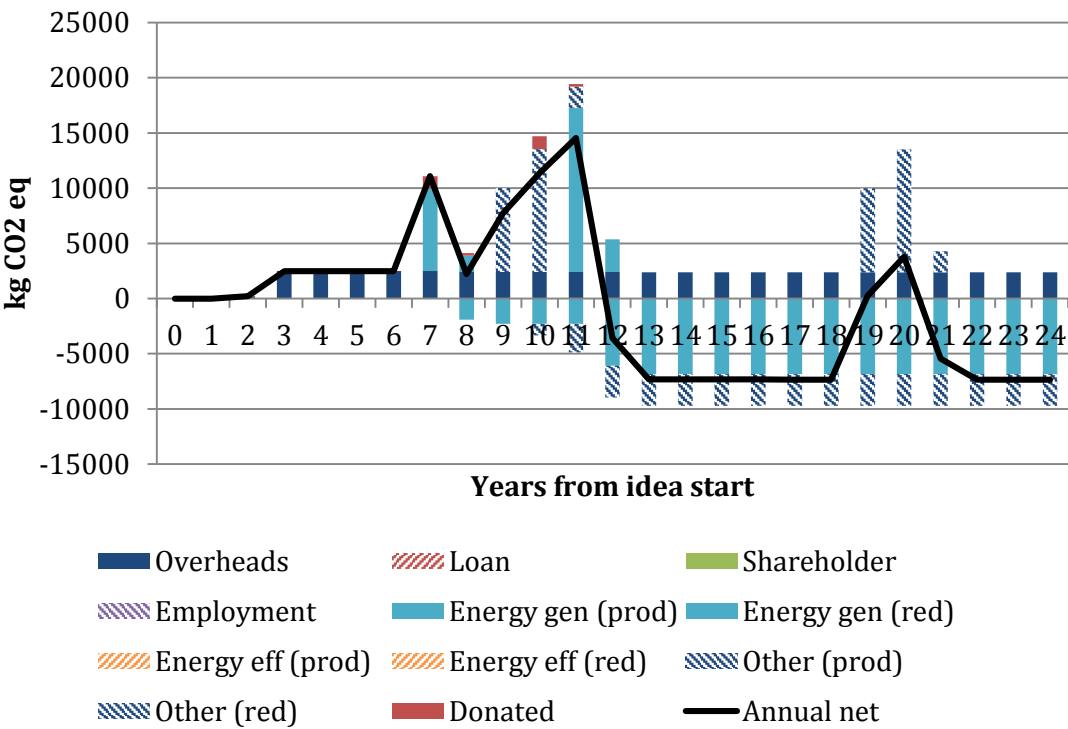


FIGURE 7-24 CARBON FOOTPRINT DUE TO INCOME USE OF TALYBONT ON UK ENERGY

7.3.13 Whalley Community Hydro

Whalley Community Hydro formed in February 2010 with the aim of installing a hydro project on the River Calder. This has been taken as the point at which the idea was conceived. The project has been assumed to have started generating in October 2014, on the basis of the group's website. The group are installing a 100 kW hydro project which they estimate will generate around 345,000 kWh of electricity per year.

The project is guaranteed an income under the feed-in tariff scheme for 20 years. The Generation tariff rate it receives has been assumed to be 17.8p according to the predicted start date. It has been assumed that the scheme will export 100% of electricity at the same rate agreed for Hexham River Hydro – around 5p per kWh. It has been assumed that the scheme is eligible to receive LECs and that the rate received for these is the same as that received by OVESCO. The average annual income is around £110,000. The generation tariff rate accounts for 75%, export 23% and the LECs 2%. The breakdown of income and spending is shown in Figure 7-25.

The group estimate that their overheads will be around 25% of income per annum, if the land rent is included. This is around £27,000 per annum. The finance for the project has been raised through a £75,000 share offer. The group plan to offer an interest rate of between 3 and 5% plus base rate. Therefore it has been assumed that the interest rate for shareholders is 4% applicable from the 3rd year. It has been assumed that the shareholders will be paid back over a 20 year period. The share offer states that shares can only be withdrawn after the 3rd year of operation. Over the time period modelled in this work, shareholders receive in total £990,000 or 45% of the income.

During the interview several possible uses for remaining income stream were put forward: additional energy generation projects and grants for sustainable businesses. It has been assumed that the excess income each year is divided equally between these two aims. The energy generation is assumed to be installed by the group and for simplicity is modelled as if they install PV. However it should be noted that ground source heat pumps were also mentioned as a possibility in the interview. The grants for sustainable businesses have been modelled as a donation as the actions taken by the business are not those of the group. In total around £25,000 is used for energy generation and the same sum in donations. These each make up around 11% of spending.

The modelled use of income by Whalley River Hydro results in the additional emissions of around 62,000 kgCO₂eq as shown in Figure 7-26. For the first 18 years, more carbon is emitted each year than saved. This is due mostly to the effect of shareholders and installation of energy generation. After this time the carbon saved each year by the energy generation has built up to a level greater than that of new carbon emissions due to the use of the income.

INDIRECT CARBON EMISSIONS RELATED TO INCOME USE

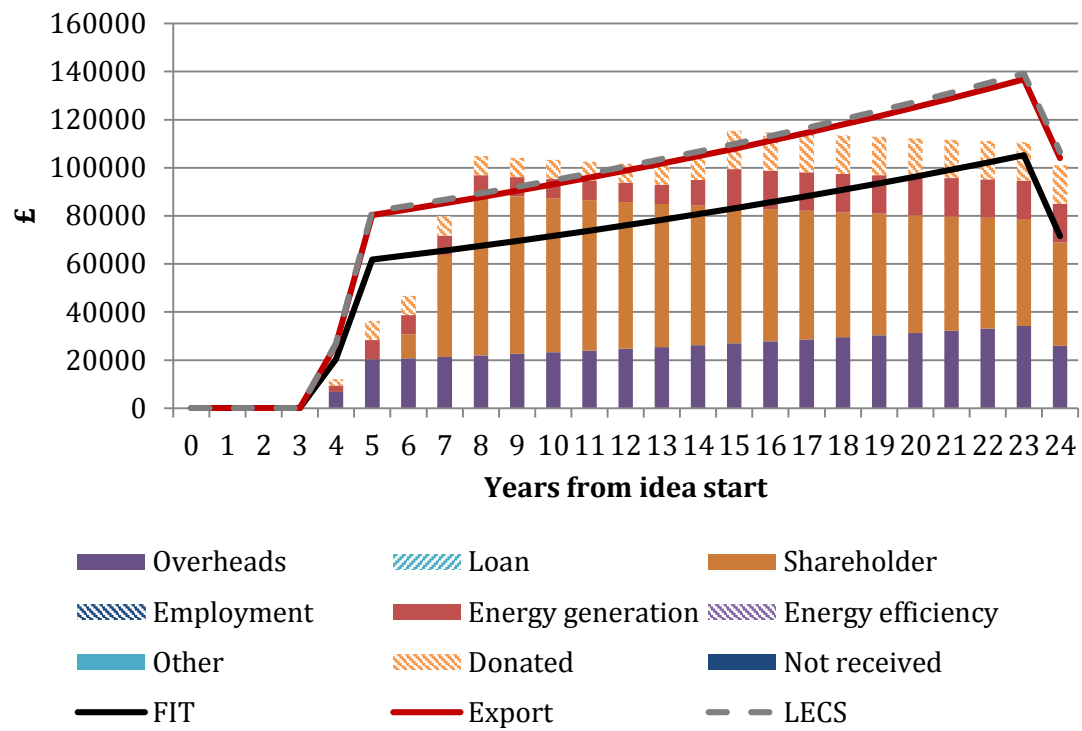


FIGURE 7-25 INCOME AND SPENDING OF WHALLEY COMMUNITY HYDRO

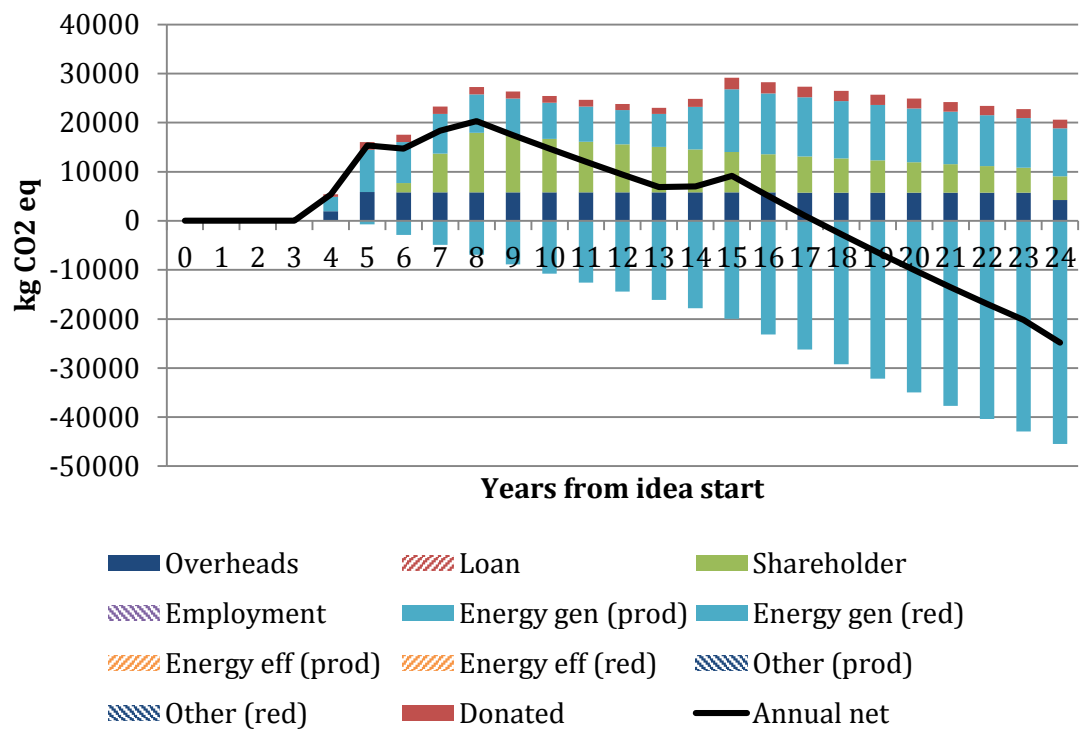


FIGURE 7-26 CARBON FOOTPRINT DUE TO INCOME USE OF WHALLEY COMMUNITY HYDRO

7.4 Summary

A number of assumptions have been made during this analysis. These will have an impact on the outcome of the analysis. For example the rate at which the shares are paid off will affect the amount of income which is spent on shareholders rather than for community benefit. Therefore care should be taken not to ascribe too much meaning to the values presented here. However the work does reveal some trends.

The majority of income of most groups is due to the generation tariff. This confirms the findings reported in Chapter 5 that the export tariff was negligible. However a higher proportion of the income comes from the export tariff for large scale projects that do not supply a building.

Currently the majority of groups let the site owner use the electricity generated for free. This is unlikely to change for current projects whilst the systems receive the generation tariff, even in the future when smart meters are installed to measure the actual export as the income from this source is low. However it may change once the generation tariff finishes if the groups are still in existence. This assumption may also change for PV projects installed after 2013 as the generation tariff rates decrease. Selling the electricity can increase the income stream significantly. In Chapter 5 it was identified that the creation of an income stream for the community appears to have become a central part of a community energy project.

Community energy projects that have been financed through community share offers use a large proportion of their income to payback these shares and the interest due on them. At the highest level of interest offered by any group, 80% of the income stream is given to shareholders. Only around 10% of the income stream from this group goes towards reducing carbon emissions in the community. This proportion of spending would not be expected looking at the proposed uses of the income streams in many share offer documents.

This analysis has shown that the income stream should not be assumed to be used to further reduce carbon emissions beyond that of the project – in the majority of cases when only the use of the income stream is considered a net emission of carbon has been modelled. Although in some cases it is uncertain if the overall effect will be an increase or a reduction as it depends on the values used to convert £ into carbon, in other cases the groups are not doing anything that would conceivably reduce carbon emissions within the time frame modelled.

Analysing the income and its use on an annual basis rather than on a total basis has illustrated that for projects financed through a share offer or loans a cash flow pinch-point occurs around 10 years of generation. This is linked to the amount of interest that is due on remaining shares. This means that these projects have a limited potential to reduce carbon emissions in the community before this point. After this point however the amount of income that can be devoted to reducing carbon emissions in the community rises rapidly, for example £5000 a year before this point and £15,000 a year afterwards. This reduces the carbon reduction potential of these actions when viewed in terms of meeting the carbon target in 2050.

CHAPTER 8 INDIRECT CARBON EMISSIONS RELATED TO ENERGY BEHAVIOUR

This chapter presents an analysis of the potential for energy behaviour change due to community energy projects. The analysis focuses on two specific types of energy behaviour that are closely linked to the main aims of community energy projects identified in Chapter 5: installation of renewable energy technology and household energy use.

The first section of the chapter presents results of analysis carried out on datasets that cover all areas in England and Wales. These datasets were used to evaluate the difference in number of domestic installs between areas with domestic only installs and areas with both community and domestic installs. They were also used to evaluate if there was any difference in electricity use and gas use changes between these two types of area. The second section of the chapter presents anecdotal evidence collected during the interviews. There are three type of evidence described, that of installs of renewable energy, energy use, and community involvement in the project. The third section of the chapter presents results of analysis of energy use collected by one of the communities that participated in the research, to which access was kindly given.

8.1 National dataset

A dataset was built using a list of all lower level super output areas (LLSOA) in England and Wales. LLSOA boundaries in England and Wales are designed to have an average population of 1,600 with a target range of 1,000 to 1,800. England has around 32,000 of these areas, Wales has around 2000, (ONS). There are a total of 34,753 LLSOAs in the dataset.

Data from the Central Feed-in Tariff database, maintained by OFGEM (2013) was used to create a count and installed capacity of installs eligible for the feed-in tariff in each LLSOA. This data was broken down by type of installation: domestic, community, commercial, industrial. Installs were ascribed to each category by the company that carried out the installation and they were not provided with a definition of what constitutes a community install. OFGEM, who are responsible for maintaining the Central Feed-in Tariff database later provided a space to record whether the install was for a community or school, however at the time of data extraction, this record had largely not been completed. Therefore in this analysis it has been assumed that installations defined as community in the database fit with the definition of community energy used throughout this work. It was not possible to ascertain the validity of this assumption in this analysis. The Renewable Heat Incentive opened to domestic users on the 9th April 2014 (OFGEM, 2014), after data collection had been completed

LLSOA were given a code based on the installation type mix present in the area. There are four types of installation and therefore there are 16 possible combinations. The combinations, along with the code and the number of LLSOA which belong to each group are presented in Table 8-1.

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TABLE 8-1 POSSIBLE COMBINATIONS OF TYPES OF INSTALLS IN EACH LLSOA | 1 INDICATES AN AREA HAS THAT TYPE OF INSTALLATION, 0 INDICATES AN AREA DOES NOT HAVE THAT TYPE OF INSTALLATION | THE AREA COLUMN IS A COUNT OF AREAS WITH THAT COMBINATION OF INSTALLATIONS

Industrial	Commercial	Community	Domestic	Code	Areas
0	0	0	0	0	3874
0	0	0	1	1	24889
0	0	1	0	2	50
0	0	1	1	3	838
0	1	0	0	4	172
0	1	0	1	5	4160
0	1	1	0	6	6
0	1	1	1	7	354
1	0	0	0	8	9
1	0	0	1	9	165
1	0	1	0	10	0
1	0	1	1	11	12
1	1	0	0	12	1
1	1	0	1	13	201
1	1	1	0	14	0
1	1	1	1	15	22

Gas and electricity consumption and the number of meters in each LLSOA in England and Wales were obtained from the Department of Energy and Climate Change website. Data were available at this level for the years 2008 to 2012. Much of the data is classified by DECC as experimental and may therefore be updated with newer versions.

Descriptive data about each LLSOA was gathered from a number of sources and added to the dataset. Population, households and area was obtained from the Department of Energy and Climate Change website. The Rural/Urban classification and household ownership status was taken from the 2011 UK census.

Multiple indices of deprivation are a representation of how deprived an area is compared to another area. Multiple deprivation covers a wide range of ideas, i.e. income, living environment, crime. Countries within the UK have their own methodology for calculating a multiple indices of deprivation and so are not directly comparable. Multiple indices of deprivation were also added to the dataset. The England indices 2010 is based on 2001 census LLSOA areas and the Welsh indices 2011 is based on 2001 census LLSOA areas. A copy of the first few rows and columns of the dataset is included in Appendix E, Table E.1. The following analysis has been carried out using R Software version 3.1.2 (R Foundation, 2014).

8.1.1 Renewable energy installations

It has been speculated that a benefit of community energy project is that it could encourage additional households in the area to install renewable energy. This hypothesis was investigated using the national statistics dataset to compare the number of domestic installs in different areas. The national dataset was investigated, where possible, for correlations, other than the mix of install types, which affect the number of domestic installs.

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Table 8-2 shows correlations between the number of domestic installs, the installed capacity of domestic installs and area descriptors (excluding nominal descriptors). Here variables with values of greater than + or – 0.5 are considered to be strongly correlated and these have been highlighted in the table. As is expected all variables are strongly correlated to themselves. Strong correlations are found between the number of domestic installs and domestic installed capacity and between the number of households and the population. Neither of these correlations is unexpected and should not affect the hypothesis under investigation. It may be surprising that there isn't a correlation between the number of households and the number of domestic installs. This may be because each area has roughly the same population and therefore number of households.

TABLE 8-2 CORRELATIONS FOR COMPLETE DATASET, WITH STRONG CORRELATIONS HIGHLIGHTED (GREATER THAN +/-0.5)

	Domestic count	Domestic Installed Capacity	Household	Population	Area	Ownership
Domestic count	1.00	0.913	0.192	0.137	0.304	0.201
Domestic Installed Capacity	0.913	1.00	0.192	0.150	0.390	0.284
Household	0.192	0.192	1.00	0.743	0.158	-0.228
Population	0.137	0.150	0.743	1.00	0.151	-0.232
Area	0.304	0.390	0.158	0.151	1.00	0.124
Ownership	0.201	0.284	-0.228	-0.232	0.124	1.00

Correlations are sensitive to outliers and consequently it is suggested to visually inspect the data as well (Moore and McCabe, 2003). Inspection of Figure 8-1 shows the all the variables Table 8-2, does as well as deprivation, but for a random sample of 250 areas. The strong correlations identified from the table are visible again in the figure. There is a strong positive correlation between household ownership and multiple indices of deprivation; this is not surprising as household ownership is included as a scoring factor to calculate the multiple indices of deprivation. It is possible that the correlations between the domestic count and area and domestic installed capacity and area have been affected by a few large outliers. Although the table indicates only a weak correlation between household ownership and domestic count, the graph of this relationship indicates that as the level of household ownership in an area increases the potential for higher numbers of domestic installs also increases. It is a possibility that areas with different levels of household ownership have a different potential to respond to community energy by installing

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domestic systems. Therefore areas will be split into 2 groups based on a high ($\geq 50\%$) or low ($< 50\%$) level of household ownership.

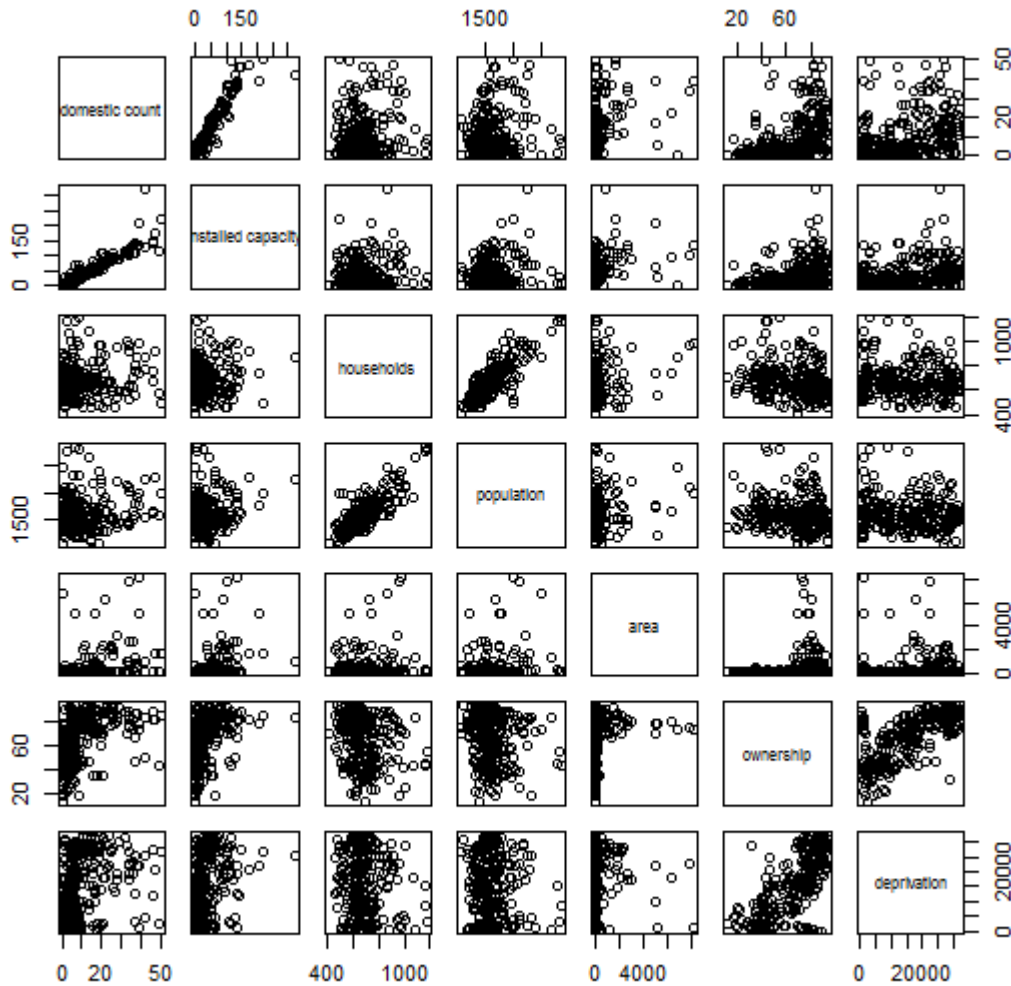


FIGURE 8-1 VISUAL CORRELATION FOR A RANDOM SAMPLE OF 250 AREAS

The hypothesis that areas with community energy projects have a higher number of domestic installs was investigated using the national statistics dataset to compare the number of domestic installs in 3 different types of areas: domestic only, community and domestic and commercial and domestic. Industrial and domestic areas were excluded due to the low number of areas with this combination. Areas which included a mix of types were also excluded.

A sample size of 150 for each strata was selected using G*Power 3.1 software for a two-tailed Mann-Whitney test between domestic only ($m_d=10$, $\sigma_d=12$) and community and domestic areas ($m_c=14$, $\sigma_c=14$), with a power of 80% and a significance of 0.1.

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TABLE 8-3 NUMBER OF AREAS FALLING INTO EACH GROUP, SAMPLE SIZE IS SHOWN IN []

	Domestic only	Community & Domestic	Commercial & Domestic	Industrial & Domestic
<50% ownership	5062 [150]	142 [142]	641 [150]	18 [0]
>=50% ownership	19827 [150]	696 [150]	3519 [150]	147 [0]

Kruskal Wallis tests were performed comparing across the three groups in each band of ownership. The results of these tests are presented in Table 8-4. As multiple tests are carried out the level of statistical confidence was corrected using the Bonferroni correction and was considered as $p < 0.05$. The result from the test of areas with greater than 50% ownership is considered significant suggesting that there is a difference in number of renewable energy installations between areas with domestic only, community and domestic and commercial and domestic installations.

TABLE 8-4 KRUSKAL WALLIS RESULTS

	$X^2(2)$	p
<50% ownership	5.23	0.0733
>=50% ownership	21.3	2.32e-05

Post-hoc tests using Mann-Whitney were carried out on the areas with greater than 50% ownership. The results of these tests are presented in Table 8-5. As multiple tests are carried out the level of statistical confidence was corrected using the Bonferroni correction and was considered as $p < 0.02$. Areas with commercial installs where household ownership is above 50% have a different distribution of the number of domestic installs to areas with only domestic installs and areas with community installs. However there is no difference in the distribution of the number of domestic installs between domestic only areas and areas that also have a community install.

TABLE 8-5 MANN-WHITNEY POST-HOC TESTS OF AREAS >=50% OWNERSHIP

	W	p
Domestic vs Community	9724	0.0420
Domestic vs Commercial	7717	2.51e-06
Community vs Commercial	9455.5	0.0169

TABLE 8-6 MEDIAN AND INTERQUARTILE RANGE OF THE THREE GROUPS OF AREAS WITH A HIGH LEVEL OF HOUSEHOLD OWNERSHIP

	Domestic only	Community	Commercial
Min	1	1	1
1 st Quartile	5	5	8
Median	9	11	14
3 rd Quartile	15	19	22
Max	56	72	95

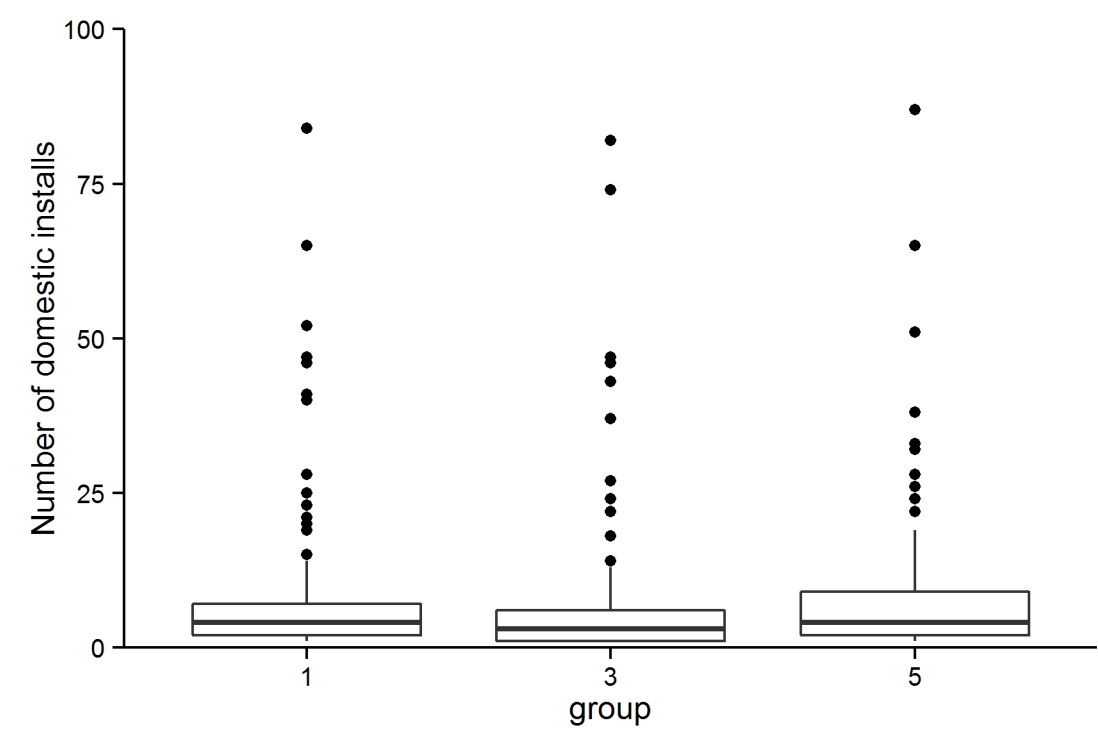


FIGURE 8-2 COUNT OF DOMESTIC INSTALLS IN AREAS WITH A LOW LEVEL OF OWNERSHIP | GROUP 1 (DOMESTIC INSTALLS ONLY); GROUP 3 (COMMUNITY AND DOMESTIC); GROUP 5 (COMMERCIAL AND DOMESTIC)

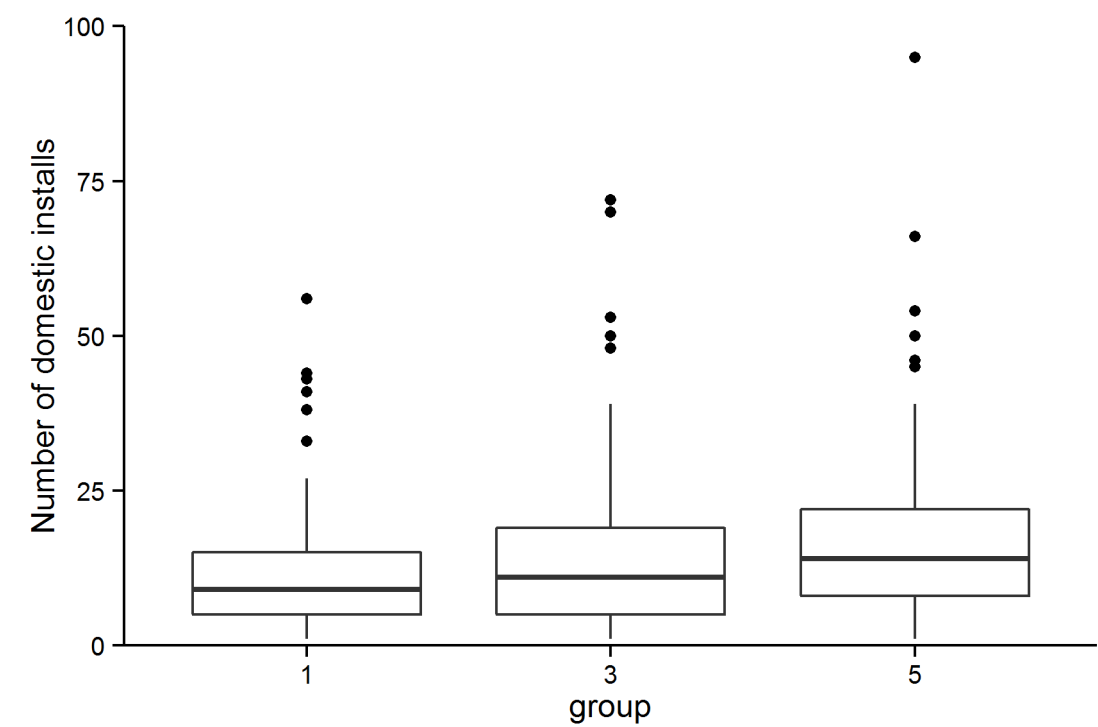


FIGURE 8-3 COUNT OF DOMESTIC INSTALLS IN AREAS WITH A HIGH LEVEL OF OWNERSHIP | GROUP 1 (DOMESTIC INSTALLS ONLY); GROUP 3 (COMMUNITY AND DOMESTIC); GROUP 5 (COMMERCIAL AND DOMESTIC)

8.1.2 Energy use

The hypothesis that energy use would decrease in areas with community energy projects due to an increase in knowledge or an increase in energy efficiency measures was tested by comparing the change in average energy use in each area between 2009 and 2012 (pre and post the introduction of the feed-in tariff). The change in both gas and electricity use was measured using the same methodology as the tests carried out for the installation of renewable energy.

TABLE 8-7 CORRELATIONS FOR COMPLETE DATASET, WITH STRONG CORRELATIONS HIGHLIGHTED (GREATER THAN +/- 0.5)

	Difference electricity use	Difference gas use	Household	Population	Area	Ownership
Difference electricity use	1.00	0.025	0.038	0.061	0.029	-0.11
Difference gas use	0.025	1.00	-0.0079	-0.029	-0.15	-0.013
Household	0.038	-0.0079	1.00	0.72	0.090	-0.25
Population	0.061	-0.029	0.72	1.00	0.11	-0.20
Area	0.029	-0.15	0.090	0.11	1.00	0.14
Ownership	-0.11	-0.013	-0.25	-0.20	0.14	1.00

There are no correlations between the different categories that are apparent in Table 8-7 beyond those expected. Inspection of Figure 8-4 does not reveal any other apparent correlations.

The hypothesis that areas with community energy projects have decreased their energy consumption more than areas without community energy projects was investigated using the national statistics dataset to compare energy use in the same three groups investigated previously. The same sample size was used.

Kruskal Wallis tests were performed comparing across the three groups. The results of these tests are presented in Table 8-8. Neither of the results is considered significant ($p > 0.1$). Figure 8-5 and Figure 8-6 show respectively the median change in gas and electricity use in the three different areas. There is little difference between the three areas.

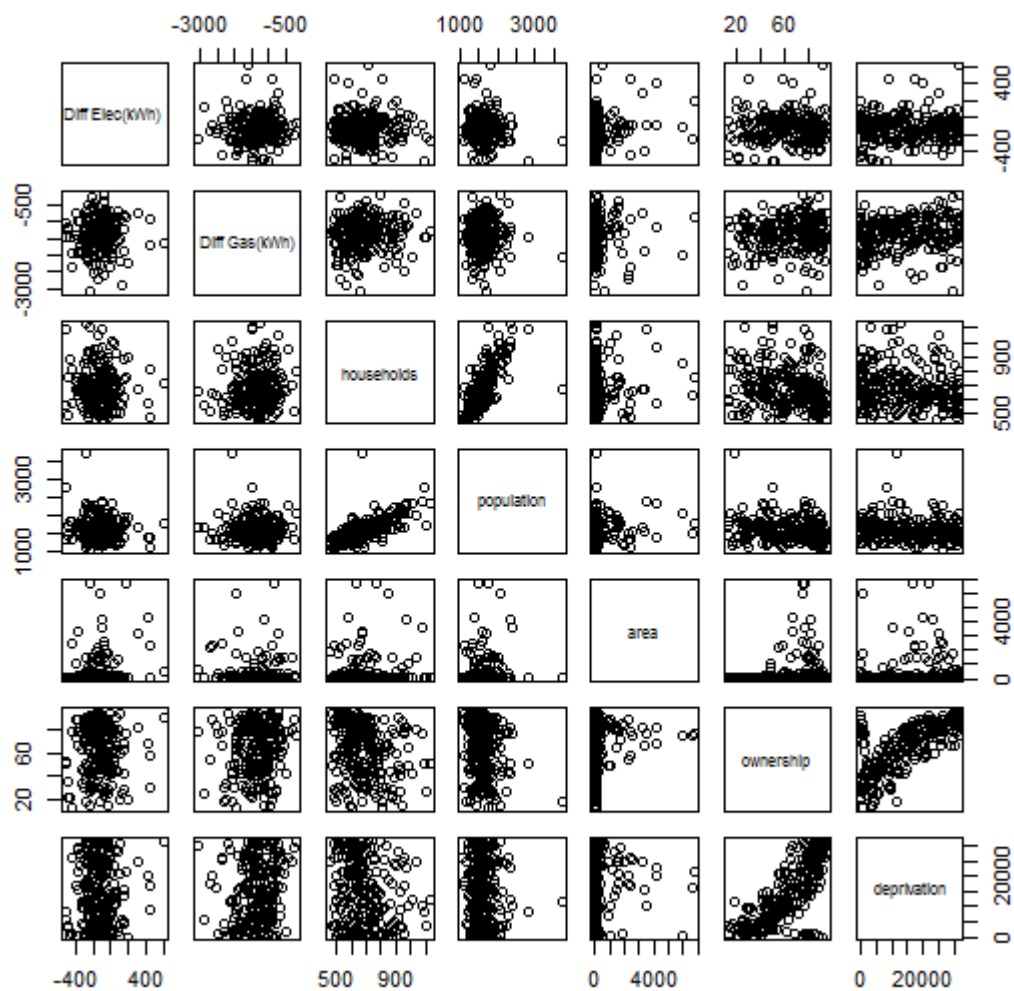


FIGURE 8-4 CORRELATION OF DIFFERENCE IN ENERGY USE WITH AREA CHARACTERISTICS OF A RANDOM SAMPLE OF 250 AREAS

TABLE 8-8 KRUSKAL WALLIS RESULTS

	$X^2(2)$	p
Gas	2.2	0.33
Electricity	3.9	0.14

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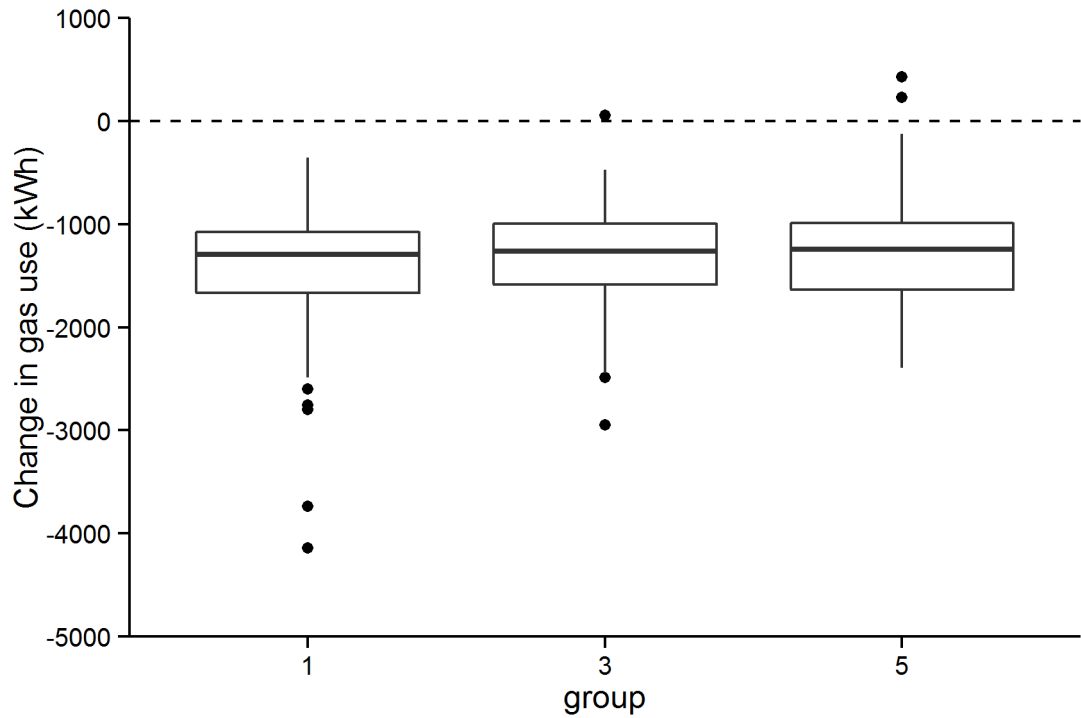


FIGURE 8-5 CHANGE IN GAS USE IN 3 DIFFERENT TYPES OF AREA | GROUP 1 (DOMESTIC INSTALLS ONLY); GROUP 3 (COMMUNITY AND DOMESTIC); GROUP 5 (COMMERCIAL AND DOMESTIC)

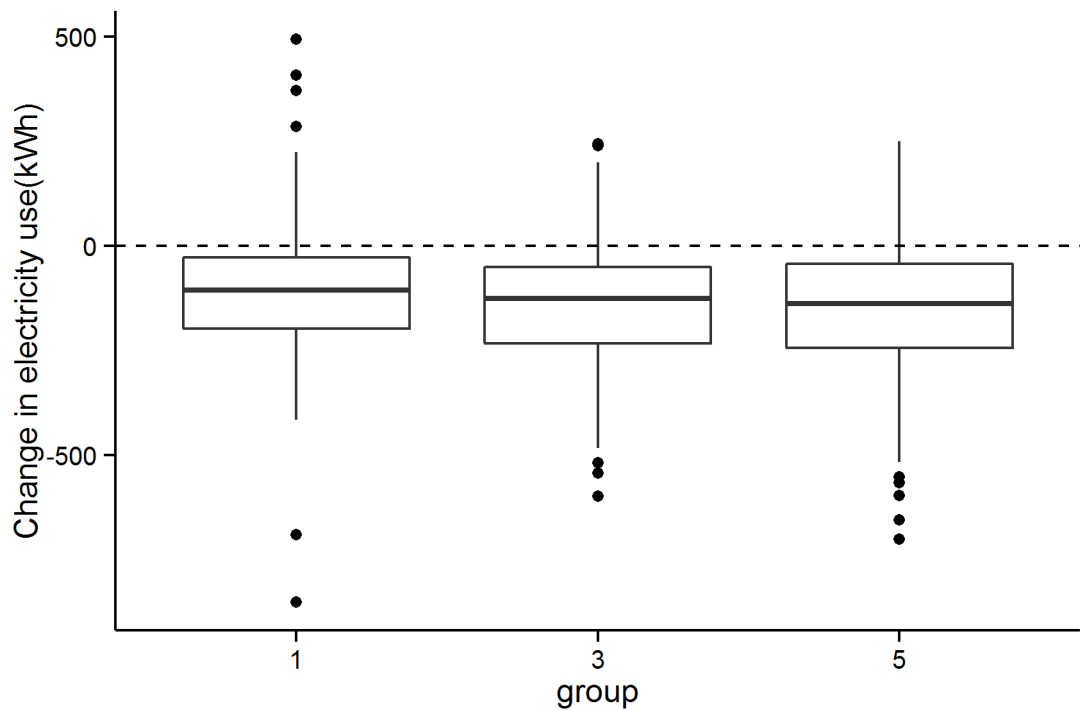


FIGURE 8-6 CHANGE IN ELECTRICITY USE IN 3 DIFFERENT AREAS | GROUP 1 (DOMESTIC INSTALLS ONLY); GROUP 3 (COMMUNITY AND DOMESTIC); GROUP 5 (COMMERCIAL AND DOMESTIC)

8.2 Anecdotal evidence from interviews

Literature reviewed during development of the questions for interview suggested that behaviour change was considered to be a benefit of community energy projects. Therefore a question asking the interviewee what they perceived as the benefit of their project was expected to elicit some response about behaviour change. However behaviour change was not specifically highlighted by any interviewee as a benefit of their project. The majority however suggested that they hoped that the projects would lead to an increase in awareness about either energy or carbon emissions. Two questions, about local support and about the potential to carry out some energy monitoring in the area, prompted limited discussion with some interviewees. A summary of these discussions that related to the two types of behaviour considered in this chapter is presented in Table 8-9.

Two groups had monitored energy consumption of some households in the area. One had found some reduction in the area although this was connected to a different activity of the group. The other group were yet to analyse their results although felt that they may show that energy consumption had increased. Two groups highlighted actions that had been taken that should lead to a reduction in energy consumption, however it was noted that these activities were not directly linked to the project.

Most groups were sceptical about the potential for monitoring energy use in the community. They typically felt it was either very difficult or impossible for the groups to do with the resources available. One scheme for monitoring energy had been funded through a £5,000 grant from Small Lottery funding and it was estimated by the group that the costs would have been higher if the developer hadn't done so much of the work pro bono. Recruiting sufficient households had been an issue for some community groups that had attempted to monitor energy use and was a concern for those that hadn't tried. Despite this seven of the groups initially indicated that they were either happy for energy monitoring of households in the local area to take place or for additional analysis of data that they had already collected. Only one group allowed access to the data that they had collected.

Three interviewees' highlighted cases where households in the local area had installed PV which they felt had been as a result of the project. A fourth group felt that no households had installed renewable energy as a result of the project. This may be because the installation was carried out by a separate group and may have had less local involvement. Another group felt that those in the community that had been sceptical about wind prior to the project were now less likely to be supportive due to noise problems experienced.

A review of the literature found that previous studies of community energy projects (not limited to those that generate energy) reported different findings related to attitude and behaviour change in the community. For example, Rogers et al. (2012), reported that attitude changes were limited to those involved in the project, whereas Platt et al. (2011) reported that 50% of individuals that were aware but not involved in the project would install either energy efficiency measures or energy generation. It is possible that the range of findings is due to the extent to which different community energy projects have involved the community in which they are based.

Table 8-9 presents the figures of involvement extracted from the interviews, i.e. the data represents the time at which the interview happened. The core group is made up of a small number of people across the whole sample. The median number of individuals in the core group is 6, with a total range of 1 to 14. The size of the core group does not appear to be linked to the scale of the community or the scale of the project.

The table also contains approximate numbers of those involved with each of the projects and a description of how they are involved. This list is based on answers given during the interview. The total number of those involved should be viewed with caution. Firstly the list was given during an interview setting and may not be a complete list. Secondly it is a list of those involved from the perspective of someone in the core group and is therefore not an accurate representation of everyone who feels involved. Thirdly the total has been calculated as if each category contains a unique subset of the community, however it is likely there is some overlap (i.e. volunteers are likely to also be on a mailing list). Finally it was identified in Chapter 5 that outside of the core group, the number of individuals involved change over the lifetime of the project. The projects presented here are at different stages of their development

There is a much larger range in the number of individuals involved in the project (between 4 and 4775). However there is also a large range in the level of involvement i.e. a volunteer could be sensibly described as more involved in a project than an individual who had heard of the project.

The number of people involved for the two groups at the upper end of this range is dominated by the number of voters that voted for the project in a competition run by the Energyshare website. One of these groups won the competition (based on the number of votes received) which suggests the potential scale of involvement. Interestingly the group that received the most votes has a lower population within their boundary than the other group. It could be said that voting is a low level of involvement but does indicate support of the project.

The number of shareholders is potentially linked to the size of investment required, although more data would be required to verify this. The level to which shareholders become involved in the project is likely to be highly variable – members of the core group are frequently shareholders and evidence collected by OVESCO suggest that becoming a shareholder may be the first involvement with the group. Small surveys of shareholders carried out by two community groups (OVESCO and Pennine Community Power) suggest that shareholders were motivated mainly by the ethical nature of the project rather than the financial gain.

The other categories have a wide range in variation in the way they are described and the number of people within them. However it appears as if the number of people closely involved (i.e. volunteers) is fairly small across a range of projects. This will potentially limit the extent of behaviour change that community energy projects can effect.

TABLE 8-9 NOTES ON ANECDOTAL EVIDENCE GATHERED DURING INTERVIEW

Group	Energy use	Renewable energy	No. core people	No. other people involved
Crucorney Energy Group	12 households installed of free insulation (linked to other activity)	10 PV installations	6	~11 (5) shareholders, (6) attend meetings
Easton Community Centre	No impact	No installations	1	~4 (4) data collection
Green TEA	Some energy consumption reduction (linked to other activity)	1 PV installation	10	~50 (50) households involved
Hebden Bridge Town Hall	No information	No information	14	~625 (25) volunteers, (600) members
Hexham River Hydro	No information	No information	6	~3884 (3884) votes
Llangattock Green Valleys	Feeling that energy consumption may have increased	No information	6	~355 (30) involved, (70) aware, (255) members
Low Carbon Gordano	No information	No information	5	~555 (5) volunteers, (550) mailing list
OVESCO	No resources to measure	No resources to measure	5	~250 (250) shareholders
Pennine Community Power	Unable to get households to sign up to energy monitoring	Possible increase in anti-wind sentiment	6	~65 (65) shareholders
Sheffield Renewables	No information	No information	10	~4775 (25) volunteers, (1500) supporters, (3000) votes, (250) shareholders
Snitterfield Actioning Climate Change	Some households purchased low energy appliances (linked to other activity)	37 PV installations	8	~37 (37) households
Talybont on Usk	No information	No information	8	No information
Whalley	No information	No information	4	(30) supporters

8.3 Llangattock Energy Audit

The Llangattock Energy Audit is a tool designed to track energy use trends in Llangattock. It was created by Llangattock Green Valleys to enable them to measure progress towards their target of a carbon negative community by 2015.

Residents of Llangattock had been recording their meter readings as part of the Green Streets competition and the Energy Audit was intended to continue that practice. The group aimed to get at least 10%, approximately 50 households, of the community to sign up. The group promote the Energy Audit in their monthly newsletter (sent to all members) by offering incentives, such as the chance to win a locally made, hand-turned, oak bowl (Llangattock Green Valleys, 2013). In November 2013, 68 households had signed up to the audit, however only 29 of these households had entered any readings. Other community groups in the research that had tried to recruit members of the community to participate in energy monitoring had also been unable to recruit high numbers of households.

Households within the community boundary are able to sign up to use the tool online. Users are able to record details about their house, such as the level of insulation, number of occupants etc. For the most part these details have not been filled in (*personal communication*, 2013). To reduce the work that users have to do, the energy consumption of gas and electricity is calculated by the tool from the meter readings entered. Users are able to record up to two electricity meters. There are a wide range of fuels in use in the area as not all of the community are connected to the mains gas system. Users can record the amount of energy used in kWh of oil, biomass, liquefied petroleum gas (LPG), petrol and diesel and in cubic meters of coal and wood. However the group feels there may be some confusion about the units used and how to calculate them and are concerned that some users are entering for example the kg of wood used (*personal communication*, 2013). Users are also able to enter historic energy use, although this must be done in chronological order. The energy generated from photovoltaic and solar thermal systems can also be recorded.

Users are sent an email each month to remind them to fill in the form. Initially two emails were sent per month. This achieved a higher level of response than one email however took more volunteer time (*personal communication*, 2013). Once the household has filled in the form they are able to view a visual display of their household energy consumption alongside the total consumption for those using the energy audit.

8.3.1 Energy Audit data

The analysis of the Energy Audit data contained in this work is based on a copy of the Energy Audit database created on the 5th November 2013. The database was first cleaned and anonymised. Each household was assigned a number that they retain throughout the analysis, this number is based on the order in which they joined. To create a record in the database, the Energy Audit user fills in a form containing spaces for all the fuel types. If a fuel type is not filled in, it is recorded as "NULL". If however the user clicks in a field, but does not enter a number, it is recorded as "0". Records of "0" fuel use for households that do not use that type of fuel have been removed from the database. Records of "0" fuel use for households that do use that fuel type however have been included.

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At the time of data extraction, a total of 68 households had signed up to the Energy Audit. Only 29 households however, had entered any readings. The 39 households that had not entered any data were removed from the analysis.

A record is made every time a household enters any data into the energy audit. They are asked to do this on a monthly basis although they are able to make a record at any point. The first records in the database are from January 2010. These records were made from historical data households had collected as part of the Green Streets competition. Therefore the maximum number of records for any type of fuel for one household, should be 47, assuming they signed up when the Energy Audit launched and filled in historical data from the Green Streets competition. This means that the maximum number of records made for each fuel should be 1833. Figure 8-7 shows number of records split by fuel type. Electricity and Gas have the most number of records. This is followed by wood consumption. The other types of fuel have fewer than 250 records each.

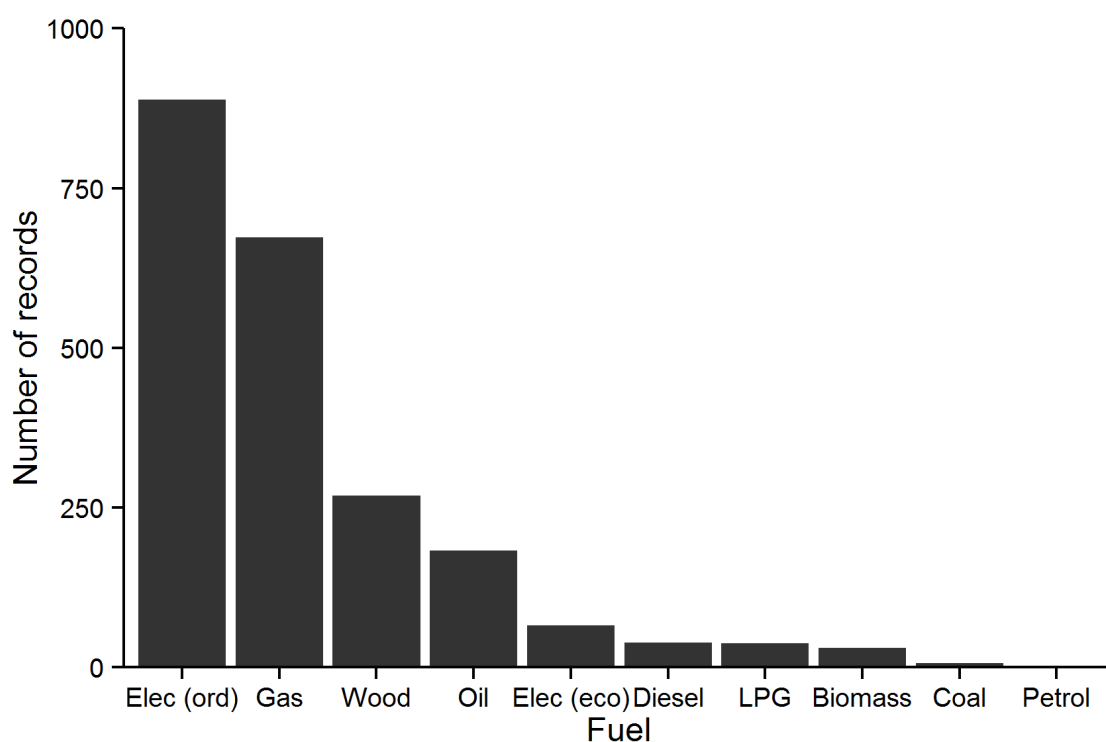


FIGURE 8-7 NUMBER OF RECORDS BY FUEL TYPE

There are a total of 2191 separate records of energy consumption. Figure 8-8 shows the number of records made by each household and by fuel type. There are two households that have made a noticeably higher number of records than the other households. This is largely due to the number of different fuel types that they have recorded. Households with an identifier higher than 041 have a smaller number of records than households with an identifier lower than this. This will be mostly because they joined later and so would be expected to have a lower number of records. However it may also partially be because those that joined later have less interest in monitoring their energy and so have not used the tool as much; 057 has made more records than the six households that signed up prior to it.

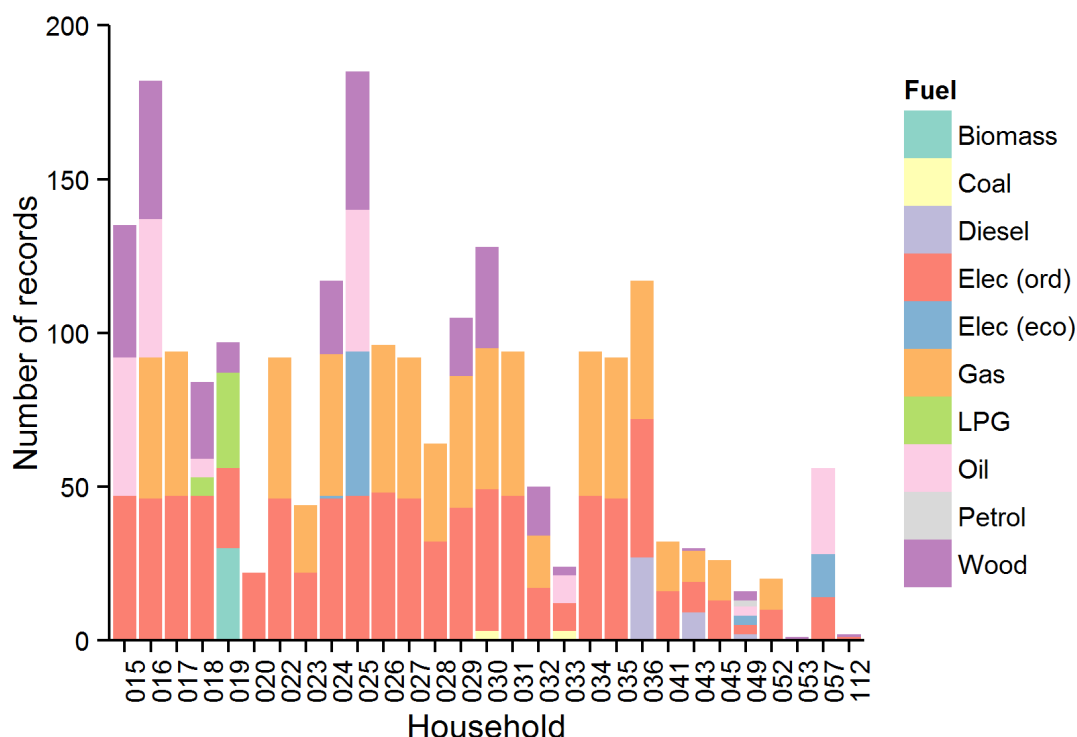


FIGURE 8-8 NUMBER OF RECORDS IN ENERGY AUDIT FOR EACH HOUSEHOLD BROKEN DOWN BY FUEL TYPE

Fuels other than electricity and gas have neither a substantial number of households or records. Therefore the following data analysis focuses on identifying the trend of gas and electricity use.

Three households are assumed to have electric heating due to their records of secondary electric meters. These households' records have been removed from the primary electricity as their profiles are likely to be different to households without electric heating.

Households are able to record their meter readings for gas and electricity or the energy they have used in a period. Meter readings were first transformed into energy used in the period between two entries. It was assumed that the daily energy used over this period was constant in order to calculate a daily energy use figure, which was recorded as happening on the day at the midpoint of the period. This assumption has a reduced validity for records made a long time apart due to the seasonality of energy use. An attempt to adjust the data to account for seasonality affects was made using heating degree data⁸ for Sennybridge monitoring station. However even after the adjustment was applied, the data was still displaying seasonality trends. Therefore the data was not adjusted prior to analysis instead a term was included in the linear regression model to reflect the seasonality affect. This was done to improve the transparency of the modelling process; one manipulation of the data was considered more transparent than two manipulations.

A study of energy use in a UK rural village suggests that to gain a representative sample of households energy use, at least 20% of households should be included in the sample. This is based

⁸ <http://www.eci.ox.ac.uk/research/energy/degreedays.php>

on taking one measurement a year over five years (Ashton Hayes Going Carbon Neutral, 2013). There are approximately 500 households in Llangattock according to Llangattock Green Valleys. Assuming the same threshold is applicable, a representative sample of Llangattock energy use is 100 households. There are a total of 24 households providing electricity readings which equates to 5.7% of Llangattock households. Similarly 19 households are providing gas readings which equates to 4.5% of Llangattock households, although not all Llangattock households have gas. This analysis therefore could not be applied to the whole Llangattock community and is representative only of those households that have taken part in the Energy Audit.

8.3.1.1 Gas use data

There were 626 records of gas use, spread across 19 households. Each household displays a large variation in daily gas use. Figure 8-9 is a boxplot of gas use for each household. It shows that the total range of daily gas use for each household is wide, however most households use a similar amount. Table 8-10 displays the median and interquartile range of daily gas use for the whole sample. The median gas use is 1.9kWh per day with an interquartile range of 3.1kWh per day. Examination of Figure 8-9, illustrates that a large number of records are considered outliers when all households are considered together.

TABLE 8-10 MEDIAN AND INTERQUARTILE RANGE OF ALL DAILY GAS USE

Min	0.0
1 st Quartile	0.74
Median	1.9
3 rd Quartile	3.8
Maximum	17

Figure 8-10 shows daily gas use for each household over the total time period the Energy Audit covers. Despite the variation in gas use between each household, four sine wave periods are clear; these correlate to what would be expected due to seasonal affects over the four years covered by the Energy Audit.

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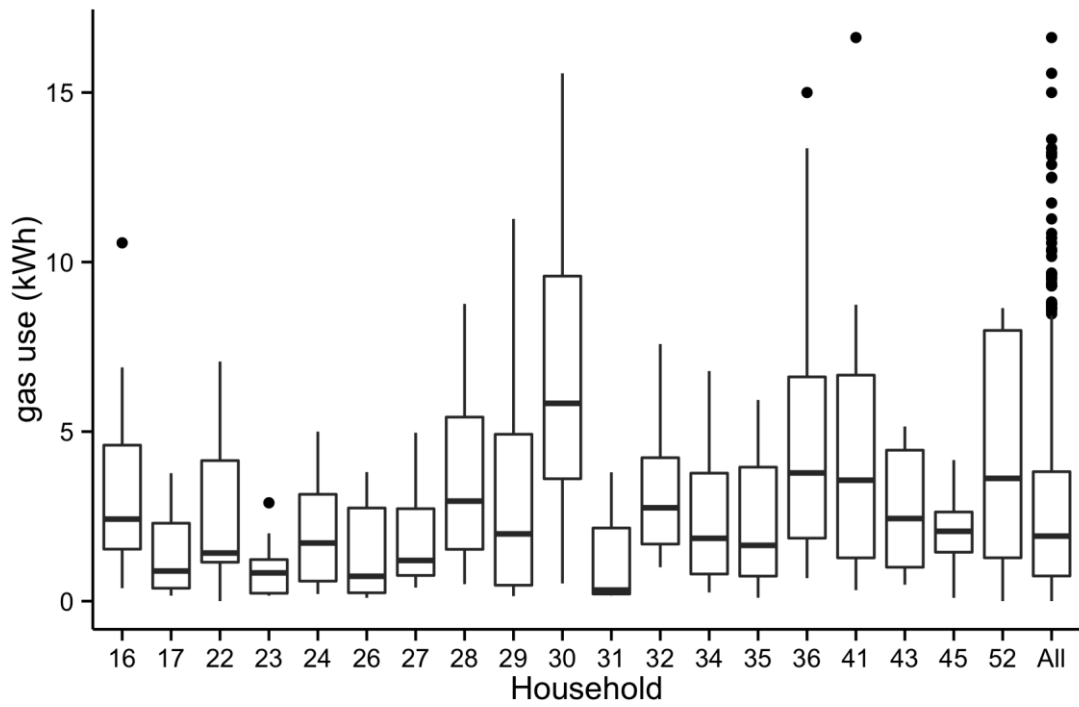


FIGURE 8-9 THE VARIATION OF GAS USE IN EACH HOUSEHOLD AND ACROSS ALL HOUSEHOLDS

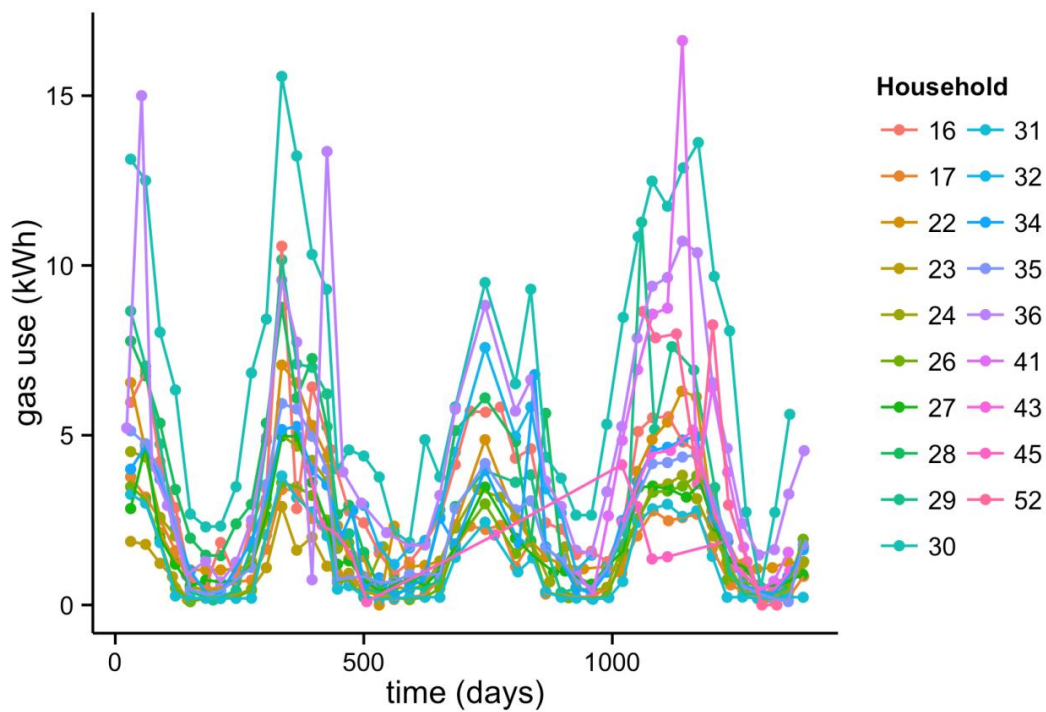


FIGURE 8-10 GAS USE FOR ALL HOUSEHOLDS OVER TIME

8.3.1.2 Electricity use data

Electricity use was recorded in 27 households. Three households who had secondary electricity meters, likely to be used for heating purposes were removed, leaving records from 24 households. The total number of records from these households was 789.

Figure 8-11 is a boxplot of electricity use for each household. It shows much higher variation than that of gas use: both within household variation and between household variation. Table 8-11 displays the median and interquartile range of daily electricity use for the whole sample. The median electricity use is 9.1kWh per day with an interquartile range of 7.9kWh per day. Examination of Figure 5, illustrates that a large number of records are considered outliers when all households are considered together.

TABLE 8-11 MEDIAN AND INTERQUARTILE RANGE OF ALL DAILY ELECTRICITY USE

Min	0.0
1 st Quartile	6.1
Median	9.1
3 rd Quartile	14
Maximum	43

Figure 8-12 shows daily electricity use for each household over the total time period the Energy Audit covers. There is no seasonal variation apparent from visually inspecting this figure.

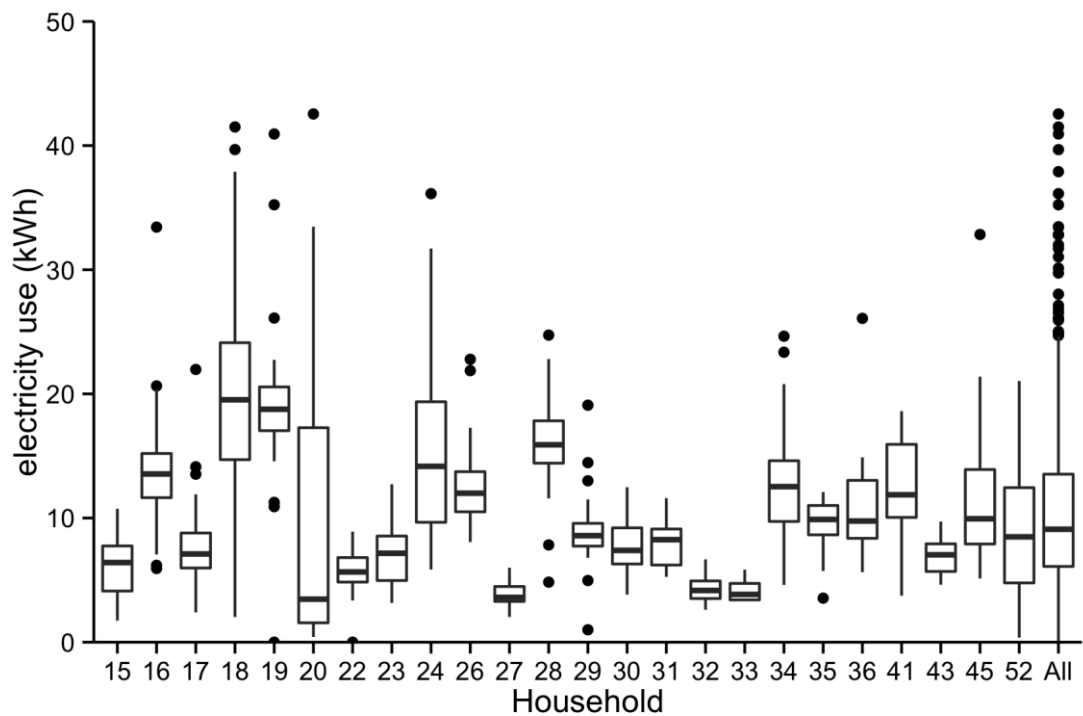


FIGURE 8-11 VARIATION OF ELECTRICITY USE IN EACH HOUSEHOLD AND ACROSS ALL HOUSEHOLDS

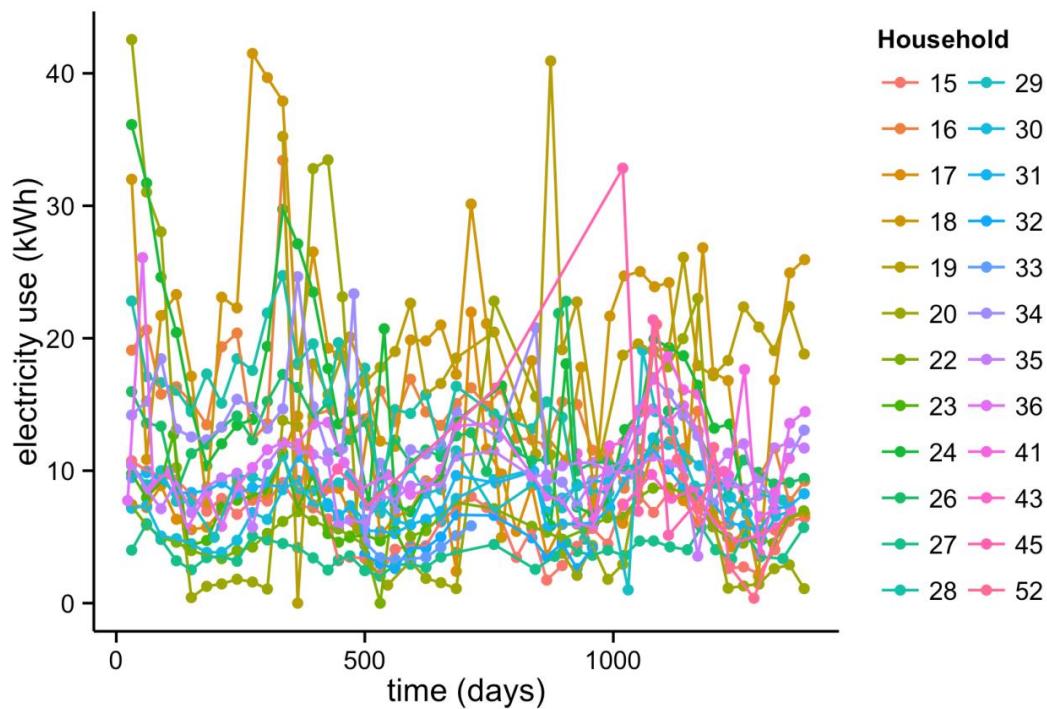


FIGURE 8-12 ELECTRICITY USE FOR ALL HOUSEHOLDS OVER TIME

8.3.2 Energy Audit analysis

Due to the irregular time period of records, time series analysis is inappropriate. Therefore a linear mixed-effects regression model was applied to the data to estimate the trend of energy use over time in Llangattock. The trend was modelled in R (R Foundation, 2014), using the LME4 library (Bates et al., 2014). Two of the most commonly used linear mixed effect models were applied to each data set (electricity and gas): a random intercept model and a random intercept and slope model (Everitt and Hothorn, 2010). The models attempted to fit two fixed effects: days since the records start and the days since records start modulated by a sine function. The first of these fixed effects represents the underlying trend of energy use. The second fixed effect represents the trend due to seasonality affects. This method of adjusting for seasonality affects means that the result is based on the area and is simpler than pre-adjusting data to remove seasonality affects using techniques such as heating degree days. However the model assumes a constant seasonality affect over a number of years.

The best model for each of the datasets was selected using the Akaike information criterion (AIC). This is a method choosing between different statistical models of a data set based on the goodness of fit of the model considered against its complexity to give a value of relative quality. A model with a smaller AIC is considered to be of better quality than a model with a higher number. For the gas data set, the random intercept model had a lower AIC (2408 compared to 2412). The random intercept and slope model for the electricity dataset had a lower AIC of 4641 (compared to 4673).

Table 8-12 shows the results of the linear mixed effects model fitted to the gas data set. There is a small negative trend associated with gas use according to the model. Figure 8-13 shows this trend,

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plotted as an orange line. The light orange area shows the 95% confidence interval. The zero trend, represented by the horizontal dotted line is included within this boundary. As such with the data available it cannot be said that the gas use trend in the community has changed over time.

Table 8-13 shows the same results for the electricity data set. Again there is a small negative trend associated with the data. However Figure 8-13 shows that the 95% confidence interval, represented by the light grey area crosses the zero trend. More data is required to say if the electricity use trend within the community has changed over time. Electricity use is more varied both between households and within households, as such the confidence interval is wider than for gas use. Therefore more households would be required to limit this interval.

TABLE 8-12 RESULTS OF A LINEAR MIXED EFFECT MODEL FITTED TO GAS (3 SIGNIFICANT FIGURES)

	Rate	2.5% confidence	97.5% confidence
Intercept	3.13	2.37	3.89
Time	-0.000152	-0.000477	0.000173
Seasonality	2.41	2.23	2.59

TABLE 8-13 RESULTS OF A LINEAR MIXED EFFECT MODEL FITTED TO ELECTRICITY (3 SIGNIFICANT FIGURES)

	Rate	2.5% confidence	97.5% confidence
Intercept	11.4	8.86	13.9
Time	-0.00140	-0.00312	0.00363
Seasonality	2.63	2.20	3.07

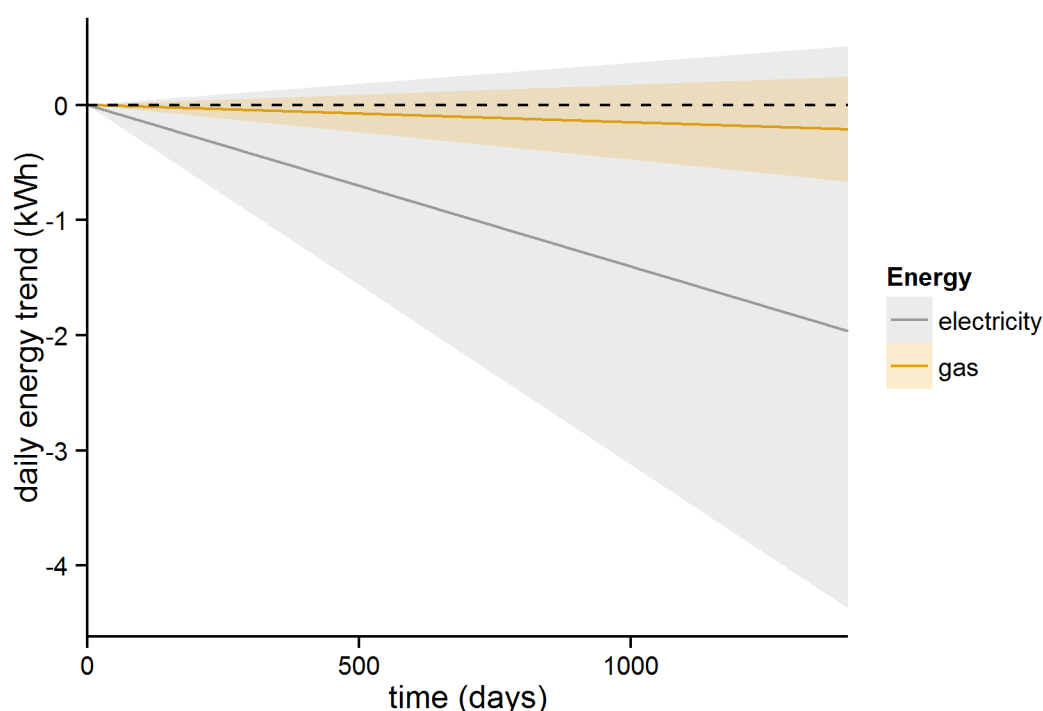


FIGURE 8-13 ENERGY TREND OF GAS AND ELECTRICITY IN LLANGATTOCK SINCE 2010 SHOWING THE CONFIDENCE BOUNDARY

Llangattock Green Valleys have set a target of achieving a carbon negative community by 2015, by becoming a net exporter of renewable energy. Figure 8-14 shows the trends calculated by the model including the intercept calculated by the model, i.e. the trends are shown in the context of

starting energy use. This graph indicates that over approximately 14kWh of energy will need to be generated every day per household in the area to achieve this target. This is roughly the equivalent of installing a 7kW PV system for every household in the area.

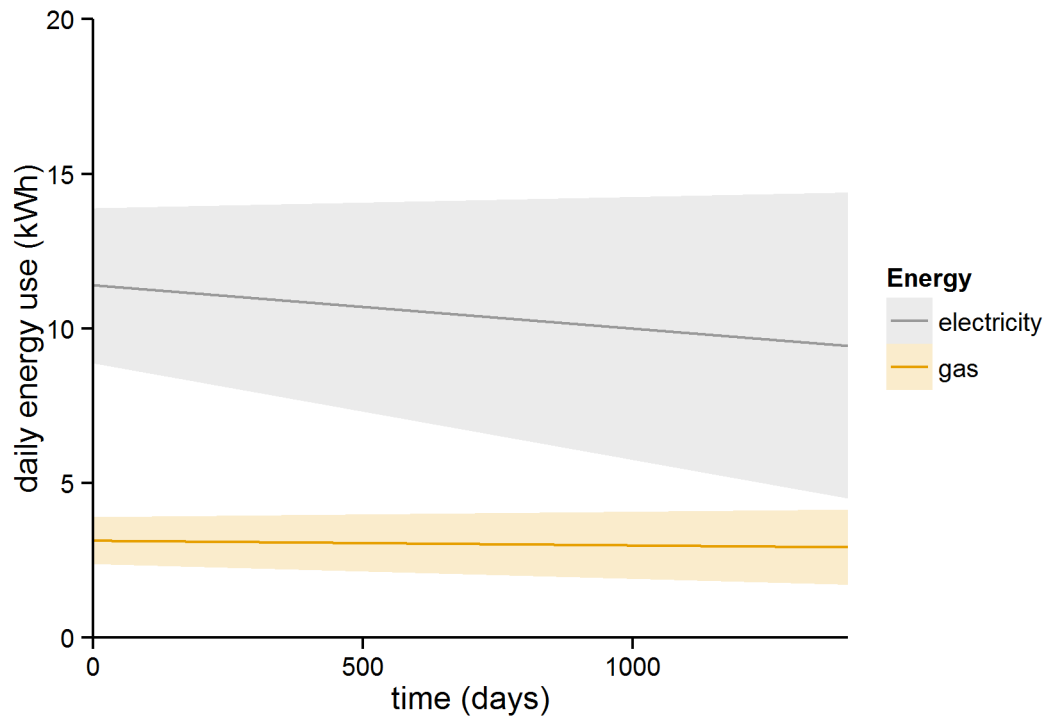


FIGURE 8-14 ENERGY TREND AND INTERCEPT OF GAS AND ELECTRICITY IN LLANGATTOCK SINCE 2010 SHOWING THE CONFIDENCE BOUNDARY

8.4 Summary

The analysis of LLSOA data presented in this chapter does not indicate conclusively any difference in the two energy behaviours studied between areas with community energy projects and areas without. This may be because the scale of the area for which the data are available is much larger than the scale at which community energy projects take place as indicated by the number of individuals involved in each project. This suggests that more research is required to evaluate the effect of individual community energy projects.

Anecdotal evidence from community groups themselves may be sufficient to show the number of additional installs within a community if they happen at the same time as the community energy project (although the number given will include those installs that would have happened regardless of the project). However it will not show the effect on an ongoing basis.

The analysis of energy consumption data from one community energy project suggests that there may have been a slight downward trend in both gas and electricity use. However more data, from a larger number of households is required in order to confirm this trend.

The analysis presented in this chapter suggests that the scale and level at which data collection should occur in order to test behaviour change due to community energy projects needs to happen at a community level. However it was also identified that community groups do not typically have the resources to do this as it costs money and takes a lot of effort to recruit sufficient numbers of households.

CHAPTER 9 CARBON FOOTPRINTS

This chapter draws together the results of the previous three chapters to create a carbon footprint of each community energy project. This meets objective 6: Calculate the carbon footprint of the recruited community energy projects, including the wider carbon emissions attributable to the project, using life cycle assessment (LCA) methodology.

The second section of the chapter compares both the absolute and per installed capacity, carbon footprints of the different groups. This gives an idea of the range of carbon footprint likely due to a community energy project

The third section compares the results of the analysis carried out for this research with results that would have been calculated using the current method. This meets objective 8: Compare carbon footprints produced using LCA methodology with those produced using current methodology, which focus on the generation phase only, to assess the validity of the current methodology as a basis for policy creation.

9.1 Community groups

This section presents the complete carbon footprint of each community energy project in turn. This allows the relative effect of the three areas to be evaluated: project, income and behaviour.

9.1.1 Crucorney Energy Group

Crucorney Energy group installed a 9.8kWp PV system on a local village hall. The carbon footprint, including the wider benefits studied, is presented in Figure 9-1. The graph shows the annual and cumulative carbon emissions associated with each part of the project over the 25 years modelled within the system boundary.

In year 0 there are no emissions associated with the project as it took approximately a year from the formation of the project idea to installation of the technology. In year 1 there is a positive net kgCO₂eq, i.e. more carbon is emitted during the year than offset. All three areas (project, income and behaviour) emit more carbon than they offset in year 1. Behaviour accounts for the majority of these emissions, around 80%. The project accounts for 19% and income approximately 1%. Behaviour in this group relates to 10 household installations of PV systems that were felt to be linked to the project.

After year 1 both the project and behaviour offset more carbon than they emit. The combined effect of these two areas is larger than the carbon emissions due to the income. Consequently after year 1 there is a net negative kgCO₂eq, i.e. less carbon is emitted than offset. As time progresses the contribution from the project and behaviour reduces as the carbon intensity of grid electricity reduces and the amount of electricity generated decreases. The relative impact of the use of income therefore becomes more important however it remains small; income accounts for 13% of the carbon footprint in year 24.

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The dashed line depicting the cumulative emissions shows that the cumulative emissions become negative in year 5. The community energy project is responsible for offsetting around 180 tonnes CO₂eq by the end of the 25 year period modelled. The project accounts for around 18%, the income 8% and behaviour 74%.

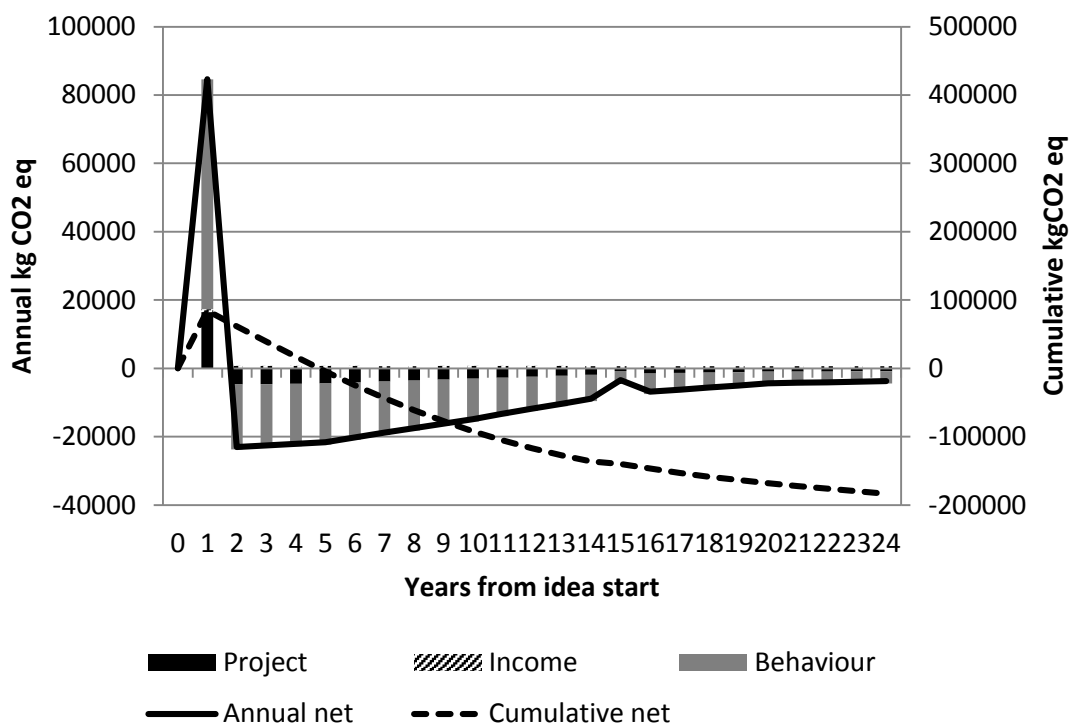


FIGURE 9-1 CARBON FOOTPRINT OF CRUCORNEY ENERGY GROUP

9.1.2 Easton Community Centre

Easton Community Centre installed 18kWp PV system. The carbon footprint of this project is presented in Figure 9-2. The only area with an effect on carbon emissions for this project is the project itself; the project accounts for 100% of the carbon footprint. The community centre does not receive any income from the system. It was felt that many of the centre's users were unaware of the PV system and correspondingly there had been no change in behaviour locally.

In year 0 there is a net positive kgCO₂eq due to the manufacture and installation of the PV system. In subsequent years there is a net negative kgCO₂eq due to the grid electricity offset. The amount of kgCO₂eq offset each year decreases over the time period modelled in this work. This is mostly due to the assumed reduction in grid carbon intensity. The reduction in electricity generated due to degradation of the PV system also contributes to this affect. In year 14 the inverter is replaced, this leads to a sudden reduction in the trend due to the embodied carbon associated with the invertor. However the annual net kgCO₂eq remains negative.

The cumulative emissions become negative around year 4 and remain negative for the rest of the time period modelled. The community energy project is responsible for offsetting around 68 tonnes CO₂eq by the end of the 25 year time period modelled.

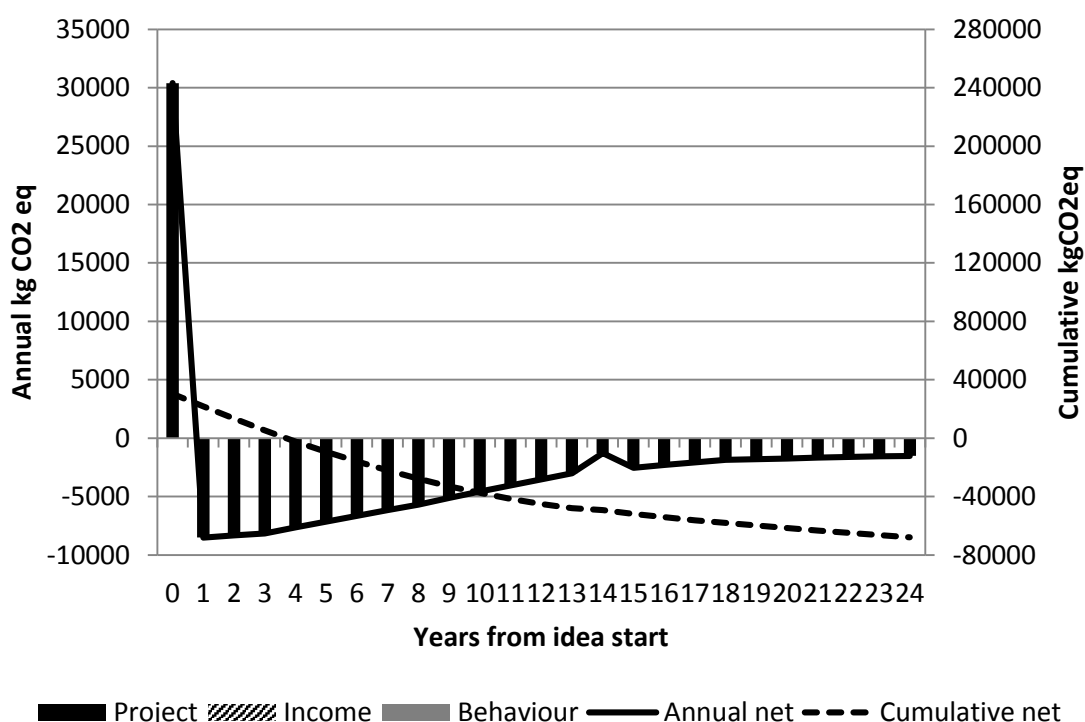


FIGURE 9-2 CARBON FOOTPRINT OF EASTON COMMUNITY CENTRE

9.1.3 Green TEA

Green TEA installed a total of 16.65kWp PV systems, split across two sites. The carbon footprint of this project is presented in Figure 9-3.

In year 0 there are no emissions associated with the project as it took approximately one year of planning before the PV systems were installed. In year 1 there is a net emission of carbon. Behaviour in the community accounts for around 68% and the project itself accounts for 32% of carbon emissions in this year. The behaviour relates to one large installation on a school that was initially planned to be part of the project. Initially the group do not receive any income and so the carbon emissions associated with this are 0 kgCO₂eq. In subsequent years the annual net emission of carbon is negative as more carbon is offset than emitted.

In year 6 the group start to receive an income. Initially the net carbon emissions associated with this are positive. However the carbon emissions are smaller than the net amount of carbon offset by the project and the behaviour and consequently the annual net emissions remain negative. In year 6, behaviour accounts for 68% of emissions, the project 31% and the income less than 1%. In year 11 the net carbon emissions due to the income become negative. The relative influence of the income grows substantially and in year 24 accounts for 54% of the annual net carbon emissions. In this year the project accounts for 14% and the behaviour 32%. There are three factors which contribute to this. The reduction in grid carbon intensity and the reduction in electricity produced by the PV systems lead to a reduction in the effect that the project and behaviour have. However the actual reduction in carbon emissions due to income use increases over time as it is invested in energy efficiency measures.

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The cumulative emissions become negative in year 6 and remain negative for the rest of the time period modelled. The community energy project offsets approximately 250 tonnes CO₂eq by the end of the 25 year time period modelled. The project accounts for around 25% of this, the income 17% and behaviour 58%.

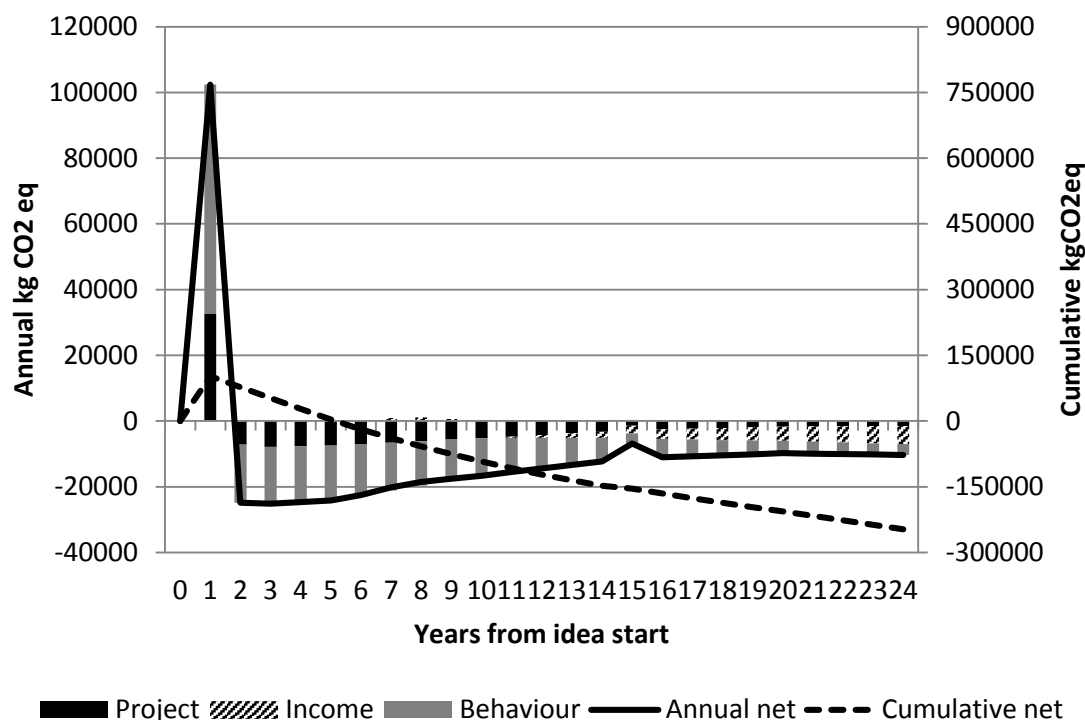


FIGURE 9-3 CARBON FOOTPRINT OF GREEN TEA

9.1.4 Hebden Bridge Community Association

Hebden Bridge Community Association installed a 4kWp PV system. The carbon footprint of this project is presented in Figure 9-4.

In year 0 and year 1 there are no emissions associated with the project as it took approximately two years from the idea forming to the installation of the PV system. From year 2 onwards, there is a positive net kgCO₂eq for the remaining time period modelled in this work, i.e. more carbon is emitted than is offset. In year 2 the majority of the carbon emissions are associated with the project (64%), compared to 36% due to the income. From year 3 onwards the project itself acts to reduce carbon emissions, whilst the income acts to increase carbon emissions – the income is spent on energy to heat and power the building. The carbon emissions associated with the income use are larger (66%) than those associated with the project (34%) and consequently the annual net carbon emissions remain positive. No information was collected about behaviour in the community and therefore no behaviour is modelled.

The cumulative emissions are positive for the entire time period modelled. The community energy project is responsible for the emission of approximately 51 tonnes CO₂eq during the time period modelled. The project accounts for around 18% of this and the income for 82%.

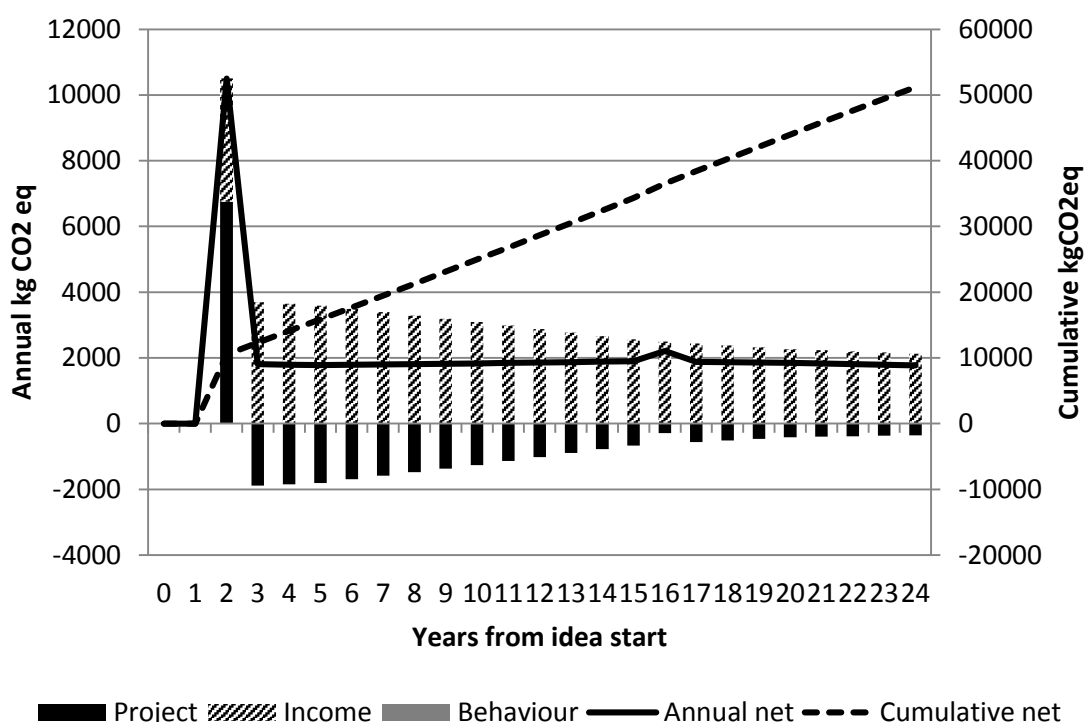


FIGURE 9-4 CARBON FOOTPRINT OF HEBDEN BRIDGE COMMUNITY ASSOCIATION

9.1.5 Hexham River Hydro

Hexham River Hydro planned to install a 100kWp Reverse Archimedean Screw on a local river. However the project was abandoned due to concerns over securing funding. The project has been modelled as if it were installed in January 2015. The carbon footprint of this project is presented in Figure 9-5. Behaviour is not modelled within this carbon footprint.

Installation of the screw occurs at the start of year 5. The income use in this year is responsible for a net emission of carbon. However the reduction in carbon emissions due to the project (82%) is greater than the increase due to the income (8%) and so the overall effect is to reduce carbon emissions. Throughout the time period modelled the annual net effect of the community energy project is negative. However as time progresses this negative effect reduces in scale. This is largely due to the reduction in carbon intensity of the grid. This effect is reduced over the last few years modelled due to a reduction in carbon emissions from income use.

The cumulative emissions are negative for the entire time period modelled. The community energy project is responsible for the reduction of approximately 2800 tonnes CO₂eq during the time period modelled. The project itself accounts for the majority of this carbon footprint (86%) compared to 14% due to use of the income.

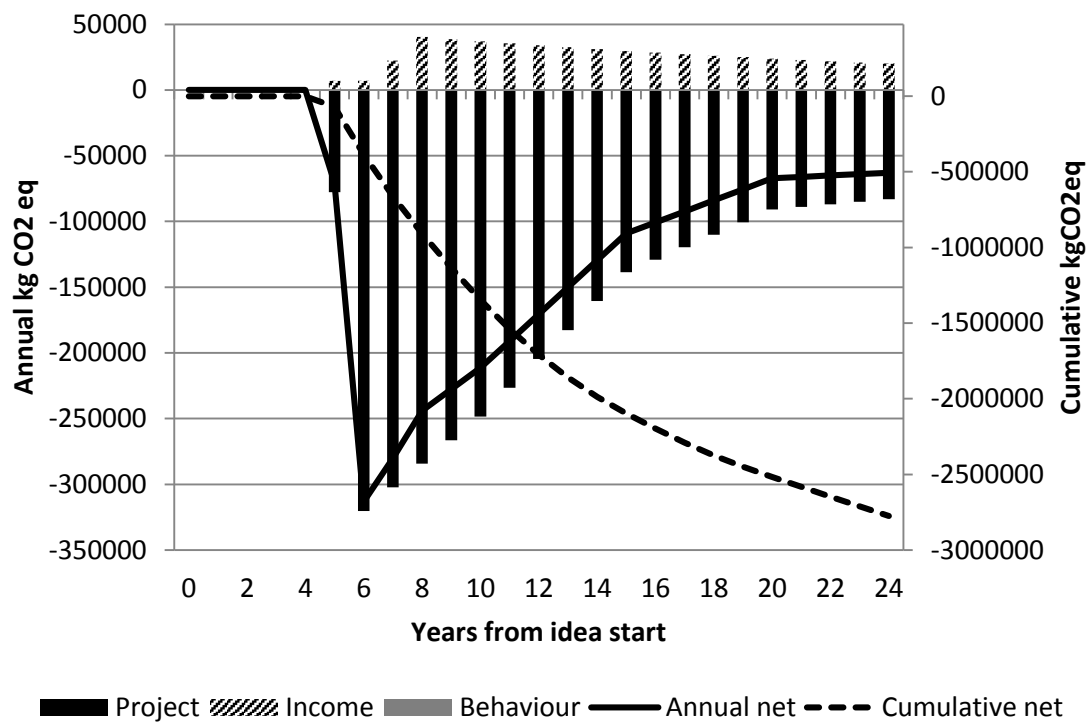


FIGURE 9-5 CARBON FOOTPRINT OF HEXHAM RIVER HYDRO

9.1.6 Llangattock Green Valleys

Llangattock Green Valleys took part in a competition where British Gas installed a 4.23kWp PV system on a community building. The carbon footprint of this project is presented in Figure 9-6.

The group do not receive any income from the project. Behaviour related to installation of renewable energy in the community was not known. The data used to examine the change in household energy behaviour was insufficient to detect if the trend was significantly different from zero. Consequently 100% of the carbon footprint of the community energy project is due to the project itself

The PV system was installed approximately one year after the idea had formed. The trends shown in the graph are identical to that for Easton Community Centre. However the system is smaller and consequently so is the magnitude of the effect.

The community energy project is responsible for the reduction of approximately 17 tonnes CO₂eq during the time period modelled.

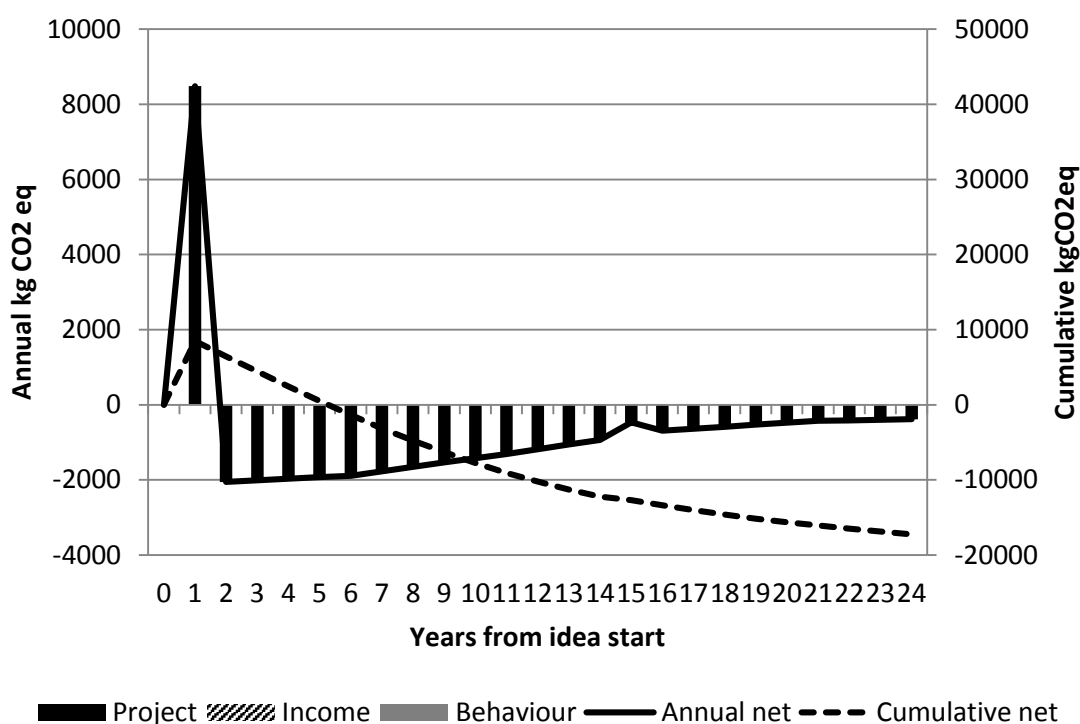


FIGURE 9-6 CARBON FOOTPRINT OF LLANGATTOCK GREEN VALLEYS

9.1.7 Low Carbon Gordano

Low Carbon Gordano planned to install an 1875kWp PV system in a local field. The project has been modelled as if it were installed in December 2014 on the basis that finance for the project was raised in late 2014. The carbon footprint of this community energy project is presented in Figure 9-7. Behaviour change is not modelled in this carbon footprint.

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This carbon footprint appears to be very similar to that of Easton Community Centre and Llangattock Green Valleys. However unlike these two projects Low Carbon Gordano will receive an income stream from the project. Until year 19, use of the income stream reduces the annual net reduction in carbon emissions. However the magnitude of carbon emissions associated with the income stream is smaller than those associated with the project itself; the average effect of the income is 8% compared to 92% from the project. Therefore the net effect of the community energy project, after the first year of installation, is to offset carbon emissions. During the final 8 years of the project modelled in this work the annual net impact is fairly constant. At this point, both the project and the income have a negative annual kgCO₂eq. Whilst the size of the impact due to the project decreases due to the reduction in grid carbon intensity, the size of the impact due to the income increases.

The line depicting the cumulative emissions shows that the cumulative emissions become negative around year 8. The community energy project is responsible for the reduction of around 4500 tonnes CO₂eq during the time period modelled. The project accounts for 93% of the carbon footprint and the income for 7%.

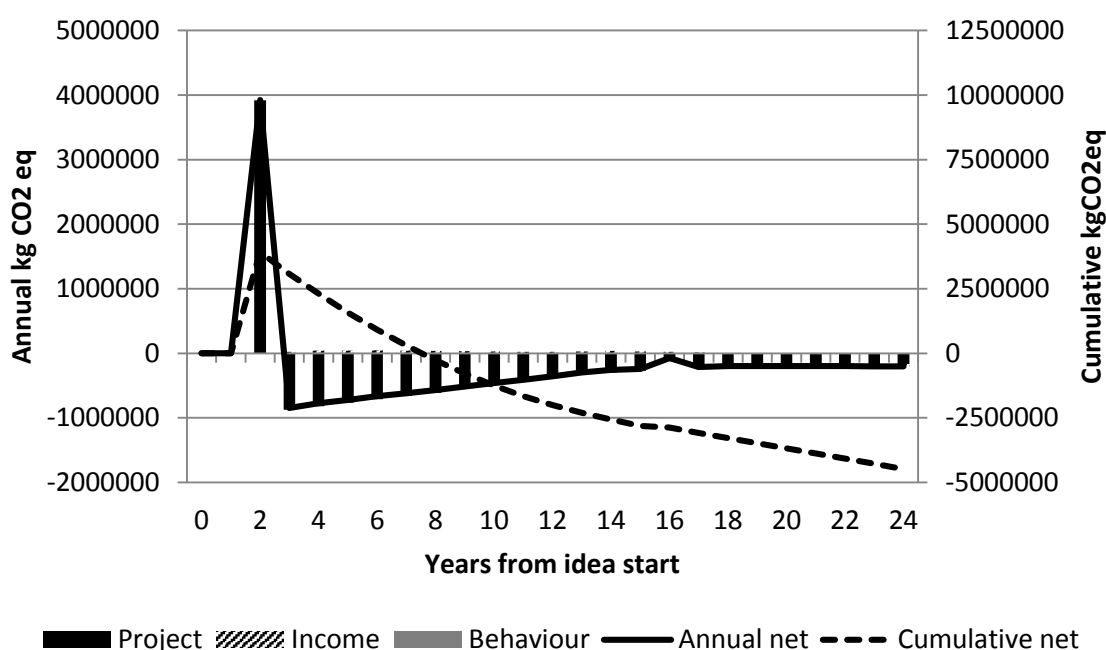


FIGURE 9-7 CARBON FOOTPRINT OF LOW CARBON GORDANO

9.1.8 OVESCO

OVESCO installed a 98kWp PV system in year 1. An additional 63.5kWp of PV systems were installed in year 2 across 3 separate sites. The carbon footprint of this community energy project is shown in Figure 9-8.

In year 1 and year 2 there is a positive net kgCO₂eq: both the project and income emit more carbon than they reduce. The project accounts for an average of 95% of all emissions during these two years and the income for around 5%. Although the income has a net emission of carbon each year

until year 21, the reduction in carbon emissions due to the project from year 3 is larger. Consequently from year 3 onwards the annual net effect of the community energy project is to offset carbon. However the amount of carbon offset annually fluctuates from around year 14. This is due to the interaction between the magnitude of the income and project: Table 9-1 shows the fluctuation in relative importance of these two areas for 3 separate years.

TABLE 9-1 FLUCTUATION IN RELATIVE IMPORTANCE OF PROJECT AND INCOME

Year	Project (%)	Income (%)
14	68	32
15	50	50
20	97	3

In year 6 the cumulative emissions due to the community energy project become negative: i.e. more carbon is offset than emitted. The community energy project is responsible for the reduction of around 440 tonnes CO₂eq during the time period modelled. The project accounts for approximately 78% of the carbon footprint and the income for 22%.

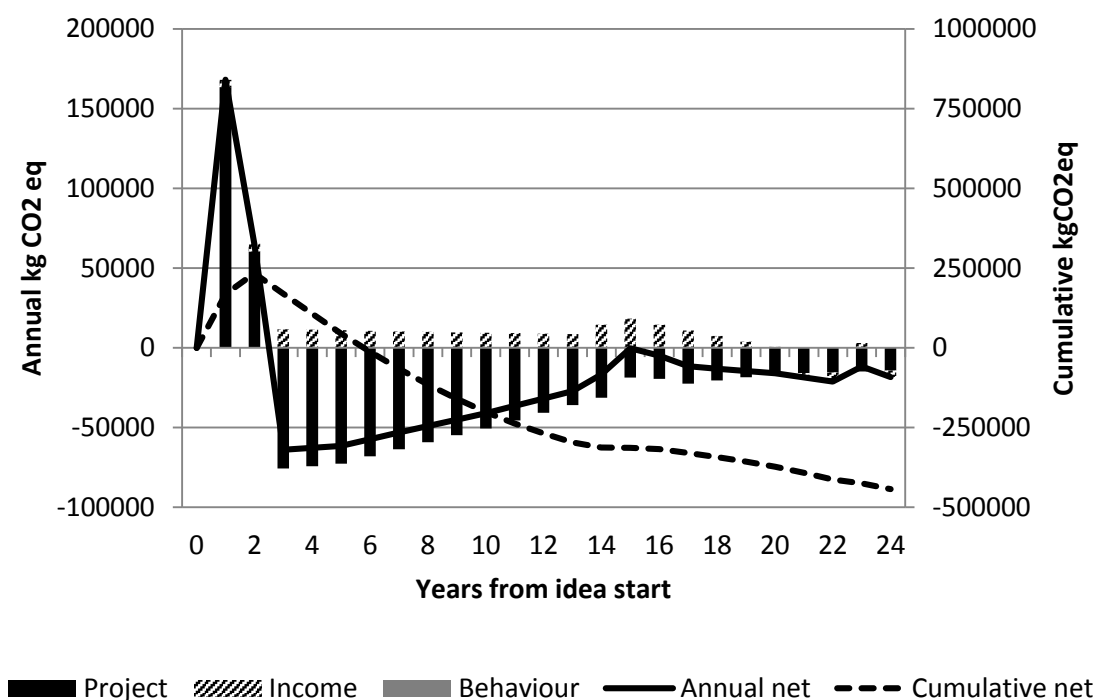


FIGURE 9-8 CARBON FOOTPRINT OF OVESCO

9.1.9 Pennine Community Power

Pennine Community Power installed a 10kWp wind turbine approximately 6 months after the initial idea. The carbon footprint of the project is shown in Figure 9-9.

The annual net carbon emission due to the community energy project is very slightly positive (approximately 30 kgCO₂eq) in year 0. In this year the effect of both the project and the income is the roughly the same however in opposite directions. After year 0 the annual net carbon emission due to the community energy project is negative as the project accounts for a much larger proportion of the footprint; 85% compared to 15% from the income. This is because the embodied carbon in the wind turbine is paid back after year 0. The annual net carbon emissions is approximately -12,000 kgCO₂eq per year over the time period modelled, however there is some fluctuation around this point (between 7,500 and 14,000). The relative effect of the income increases overtime; in year 24 the income accounts for 76% of the footprint.

The cumulative emissions due to the community energy project are negative after year 0. The community energy project is responsible for the reduction of around 260 tonnes CO₂eq during the time period modelled. The project accounts for 71% of the carbon footprint and the income for 29%.

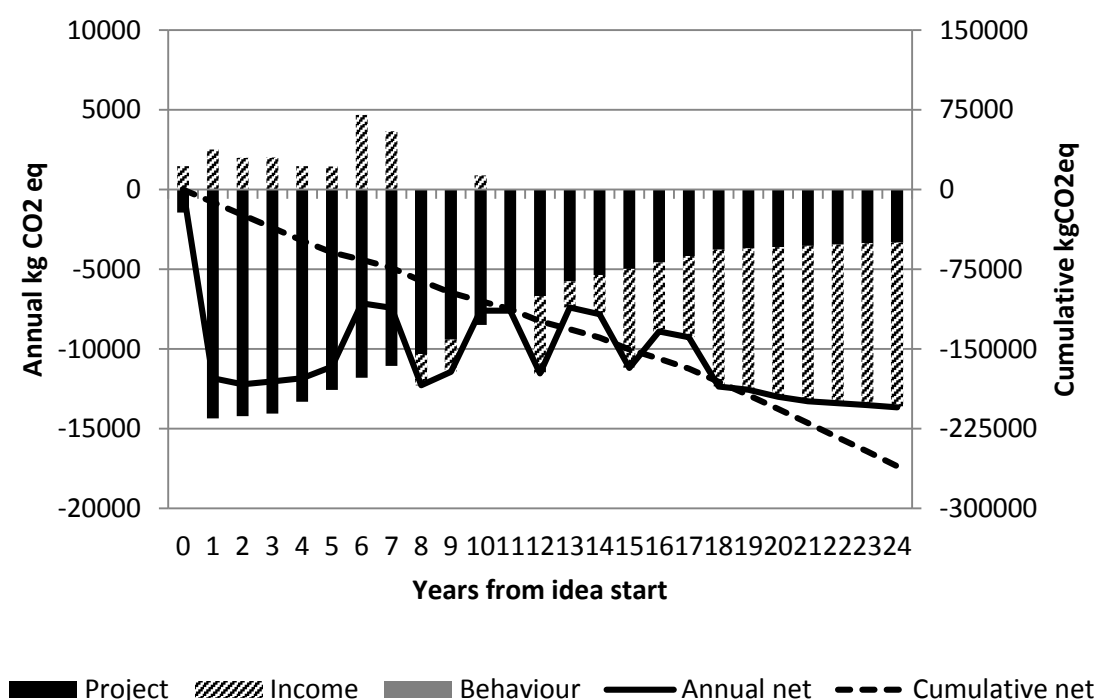


FIGURE 9-9 CARBON FOOTPRINT OF PENNINE COMMUNITY POWER

9.1.10 Sheffield Renewables

Two separate projects have been modelled for Sheffield Renewables: a hydro project and a PV project.

9.1.10.1 Hydro

Sheffield Renewables planned to install an 80kWp Reverse Archimedean Screw on a local river. However the project was abandoned due to concerns over securing funding. The project has been modelled as if it were installed in January 2015. The carbon footprint of this project is presented in Figure 9-10. Behaviour is not modelled within this carbon footprint.

Installation of the screw occurs at the start of year 6. The income use in this year is responsible for a net emission of carbon. However the reduction in carbon emissions due to the project (71%) is greater than the increase due to the income (29%) and so the overall effect is to reduce carbon emissions. Throughout the time period modelled the annual net effect of the community energy project is negative. However at time progresses this negative effect reduces in scale. This is largely due to the reduction in carbon intensity of the grid.

The cumulative emissions are negative for the entire time period modelled. The community energy project is responsible for the reduction of approximately 1600 tonnes CO₂eq during the time period modelled. The project itself accounts for the majority of this carbon footprint (89%) compared to 11% due to use of the income.

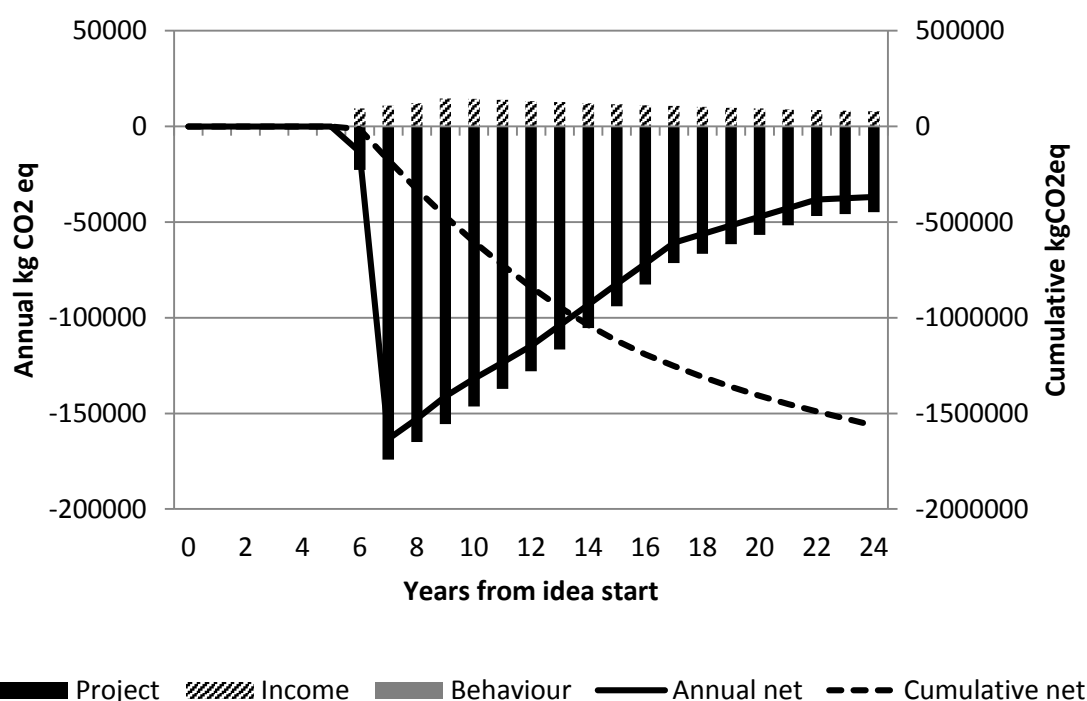


FIGURE 9-10 CARBON FOOTPRINT OF SHEFFIELD RENEWABLES: HYDRO

9.1.10.2 PV

Sheffield Renewables installed a 50kWp PV system on a local community building. The carbon footprint of this project is presented in Figure 9-11.

The annual net carbon emission associated with the community energy project is initially positive this is largely due to installation of the project in year 1. The income also plays a part and accounts for about 11% of the carbon emissions in this year. The annual net carbon emission between year 1 and year 10 is negative; due to the effect of the project. In year 10 however the annual net carbon becomes positive for one year due to the use of income. In this year the income accounts for 74% of the footprint and this is the installation of another large PV system. In years 11 to 19 the net annual carbon is negative; both the project and income are negative. However the effect of the income is larger than the project; the income accounts for between 58% and 80% of the footprint. This pattern replicates at year 20: the installation of another large PV system.

The cumulative effect of the community energy project becomes net negative in year 7. Despite the annual net carbon emissions becoming positive in some years, the cumulative effect remains negative during the years modelled in this work. The community energy project is responsible for the reduction of approximately 360 tonnes CO₂eq during the time period modelled. The project accounts for approximately 42% of the total carbon footprint whilst the income accounts for approximately 59% of the project.

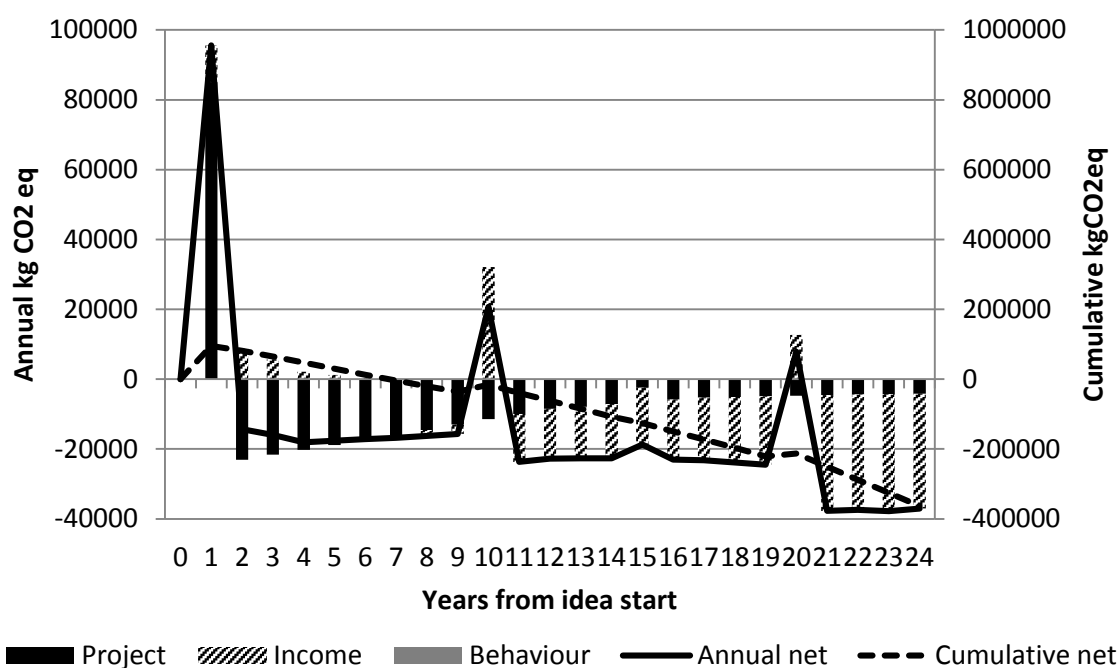


FIGURE 9-11 CARBON FOOTPRINT OF SHEFFIELD RENEWABLES: PV

9.1.11 Snitterfield Actioning Climate Change

Snitterfield Actioning Climate Change installed a total of 10.8kWp of PV systems across 3 separate sites in year 1. Figure 9-12 shows the carbon footprint of this community energy project.

Behaviour has a large effect (81%) on the overall carbon footprint of the community energy project. As the behaviour in this instance is the installation of a large number of small PV systems, the overall carbon footprint is very similar to other community energy projects where PV systems have been installed but no behaviour is affected or income received, i.e. Easton Community Centre. The contribution to the overall footprint from the income increases over time from 2% in year 1 to 46% in year 24. The effect from the project remains small throughout; a maximum in year 1 of 20%, when the PV systems are installed but then dropping to 8% in year 2 reducing to 5% in year 24.

The line depicting the cumulative emissions shows that the cumulative emissions become negative around year 5. The community energy project is responsible for the reduction of around 590 tonnes CO₂eq during the time period modelled. The project accounts for around 7% of the carbon footprint and the income for 12%. The majority (81%) of the carbon footprint is due to the behaviour.

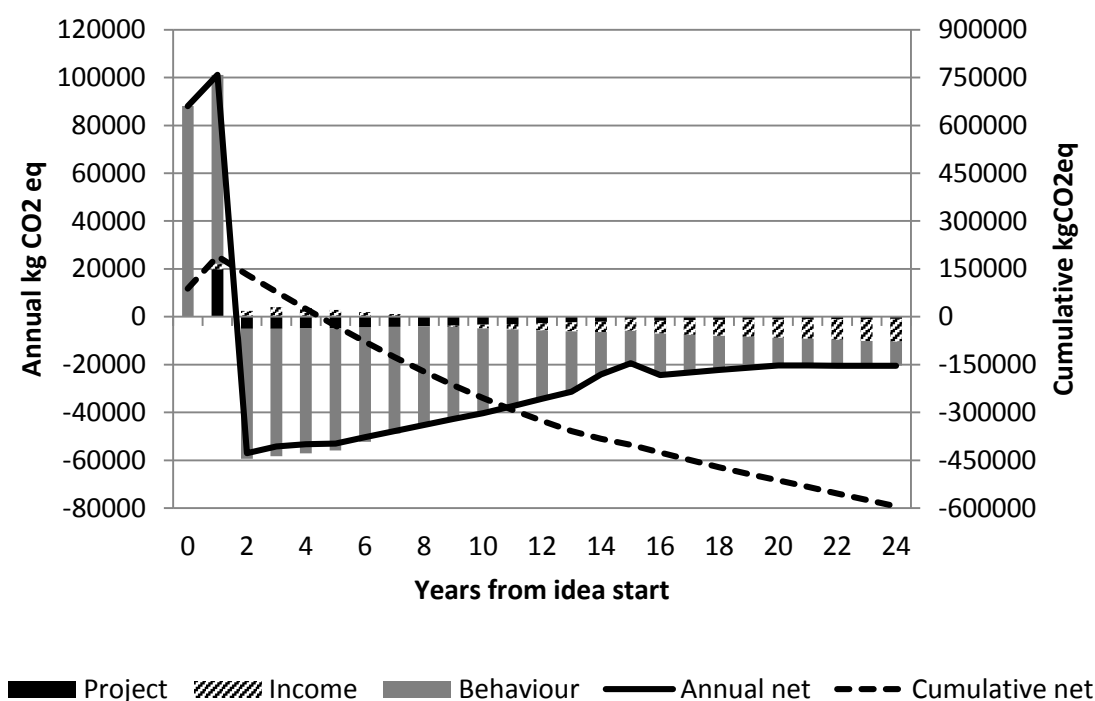


FIGURE 9-12 CARBON FOOTPRINT OF SNITTERFIELD ACTIONING CLIMATE CHANGE

9.1.12 Talybont on Usk Energy

Talybont on Usk Energy installed a 36kWp hydro turbine in the compensation flow from a local reservoir. The carbon footprint of this community energy project is shown in Figure 9-13.

In year 2 the annual net emissions are positive. Most of this, 99% is due to the project installation, less than 1% is due to emissions from income use. In subsequent years the annual net emissions

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are negative. The savings from the project outweigh the emissions due to income use. In year 12 the net emissions due to income become negative. However the magnitude is much smaller than that of the project (3% compared to 97%). Therefore as the carbon intensity of the grid decreases the annual amount of carbon savings reduces.

The cumulative emissions become negative after year 2. The community energy project is responsible for the reduction of approximately 2400 tonnes CO₂eq during the time period modelled. The project itself accounts for the majority of this carbon footprint (99%) compared to 1% due to use of the income.

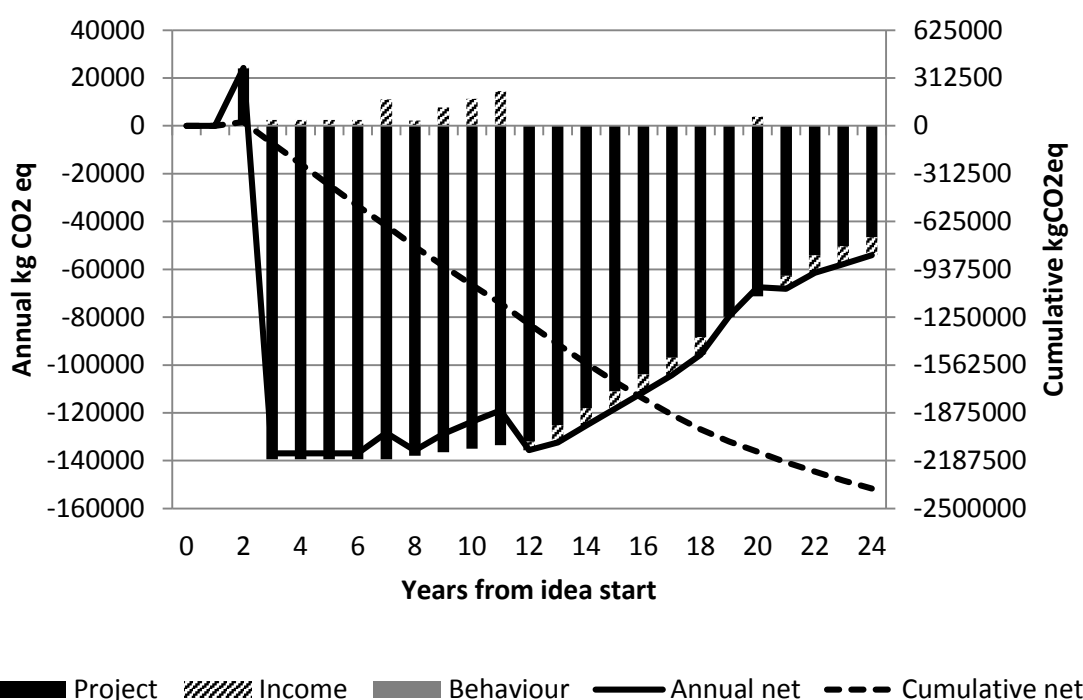


FIGURE 9-13 CARBON FOOTPRINT OF TALYBONT ON USK ENERGY

9.1.13 Whalley Community Hydro

Whalley Community Hydro installed a 100kWp Reverse Archimedean Screw in a local river. Figure 9-14 shows the carbon footprint of this community energy project.

The annual net carbon emissions are positive in year 5. This is due to the installation of the project. In subsequent years the annual net carbon emissions are negative. This is due to the large effect of the project itself offsetting grid electricity. This reduces overtime as the carbon intensity of the grid reduces. The relative impact of the income use is small: reaching a maximum of 34% in year 24.

The cumulative emissions become negative in year 5. The community energy project is responsible for the reduction of approximately 1900 tonnes CO₂eq during the time period modelled. The project itself accounts for the majority of this carbon footprint (97%) compared to 3% due to use of the income.

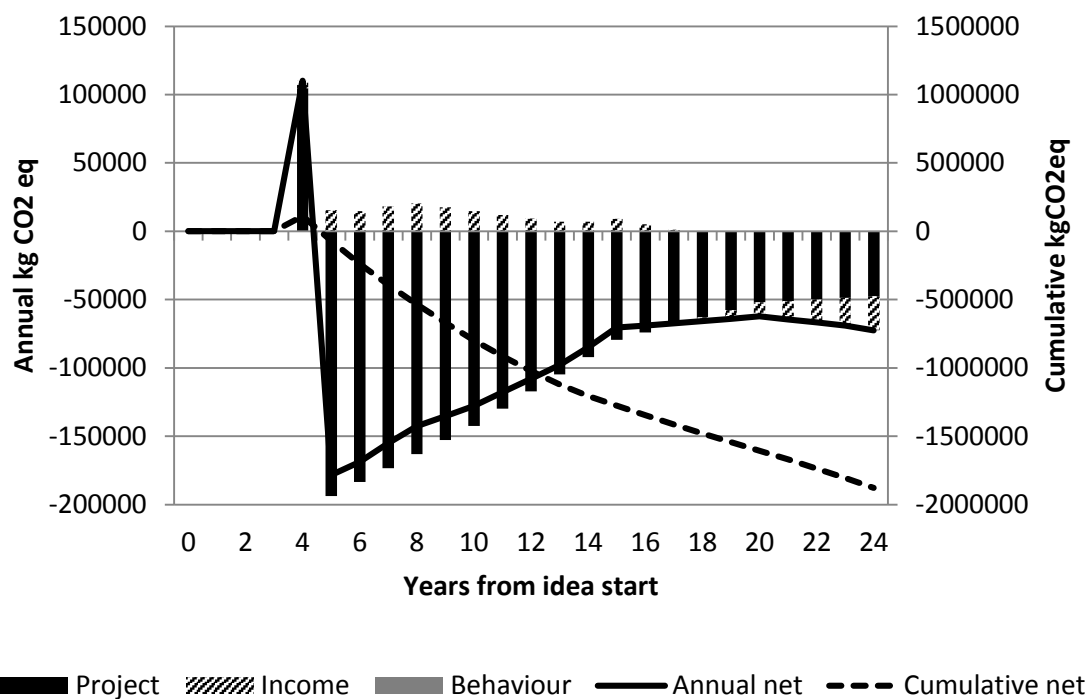


FIGURE 9-14 CARBON FOOTPRINT OF WHALLEY COMMUNITY HYDRO

9.2 Comparison between groups

Figure 9-15 shows the total cumulative emissions over time of all the community energy projects. It shows that all but one of the community energy projects leads to a reduction in carbon by the end of the time period modelled. The amount of final carbon emissions varies from 51 tonnes CO₂eq to -4500 tonnes CO₂eq and the mean is -1100 tonnes CO₂eq.

With the exception of Low Carbon Gordano's community energy project, PV projects largely lie within one band between 51 tonnes CO₂eq and -590 tonnes CO₂eq with a mean of -230 tonnes CO₂eq. The hydro projects lie within another distinctive band between -2800 tonnes CO₂eq and -1600 tonnes CO₂eq with a mean of -2100 tonnes CO₂eq.

Generally the community energy projects that lead to the biggest reduction in carbon are those with the biggest installed capacity. Low Carbon Gordano has the biggest installed capacity of all the projects and it also leads to the biggest reduction in carbon. Hydro projects typically have a larger installed capacity than PV projects. However not all projects follow this rule. The carbon reduction of hydro projects are largely affected by the amount of electricity they generate which is influenced by the site. There is more variation from this rule within PV projects. For example, Snitterfield Actioning Climate Change's community energy project has a smaller installed capacity than that of OVESCO's community energy project however it leads to a larger reduction in carbon. This is because behaviour and income have a larger influence on the carbon footprint of the projects.

Figure 9-16 shows the cumulative emissions over time of all the community energy projects but adjusted by the installed capacity of each project. The amount of final carbon emissions varies from 13 tonnes CO₂eq./kWp to -66 tonnes CO₂eq./kWp and a mean of -18 tonnes CO₂eq./kWp.

This time there is no banding of different technologies. The order of community energy projects is different to that in the previous graph. The largest community energy project has one of the lowest reductions in carbon emissions per kWp. The project with the largest saving per kWp is Talybont on Usk. This is largely based on the large amount of electricity produced per kWp due to the site conditions. However it is also the hydro project that generates for the most years within the modelled time period. Snitterfield Actioning Climate Change has the project with the second largest saving per kWp. This is due to the large behaviour change that was encouraged in the community due to the project; a large number of households installed PV systems.

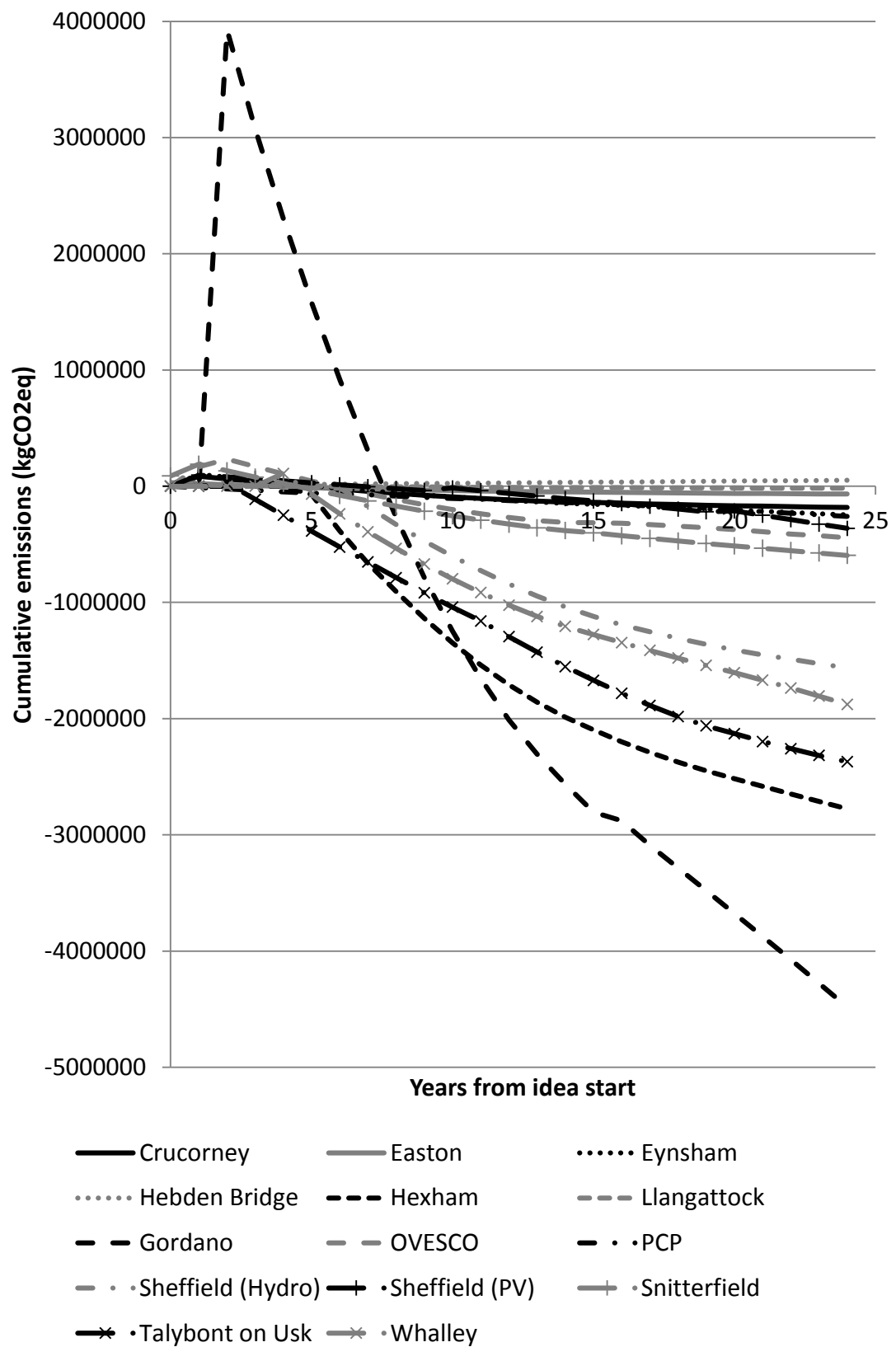


FIGURE 9-15 COMPARISON OF CUMULATIVE CARBON EMISSIONS BETWEEN GROUPS OVER TIME

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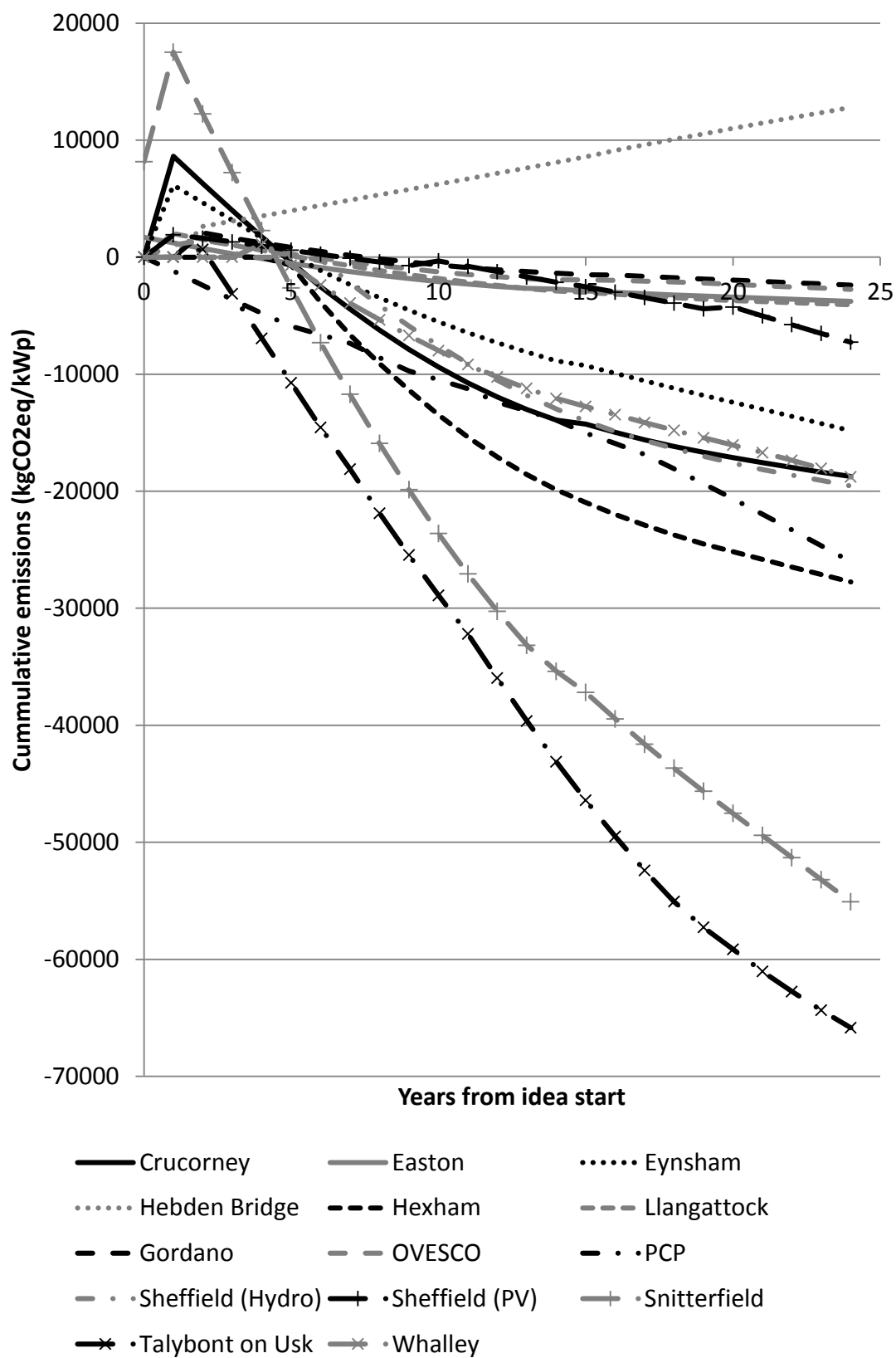


FIGURE 9-16 COMPARISON OF CUMULATIVE CARBON EMISSIONS PER KWP BETWEEN GROUPS OVER TIME

9.3 Comparison with current method

Figure 9-17 shows a comparison for every community energy project between the carbon footprint per kW calculated using LCA methodology and that calculated using the current methodology. To ensure a fair comparison the footprint calculated using the current methodology is based on the same time period. The current methodology just includes the grid electricity offset by the project. The carbon intensity of the grid used for the current methodology footprint is based on the DEFRA 5-year rolling average of 0.52 kg/kWh.

The current methodology appears to overestimate carbon savings for the majority (79%) community energy projects. For all technology types this is largely due to the assumptions made about the carbon intensity of the grid. However PV projects have currently approximately a 4 year carbon payback period which also contributes to the overestimation of the current method.

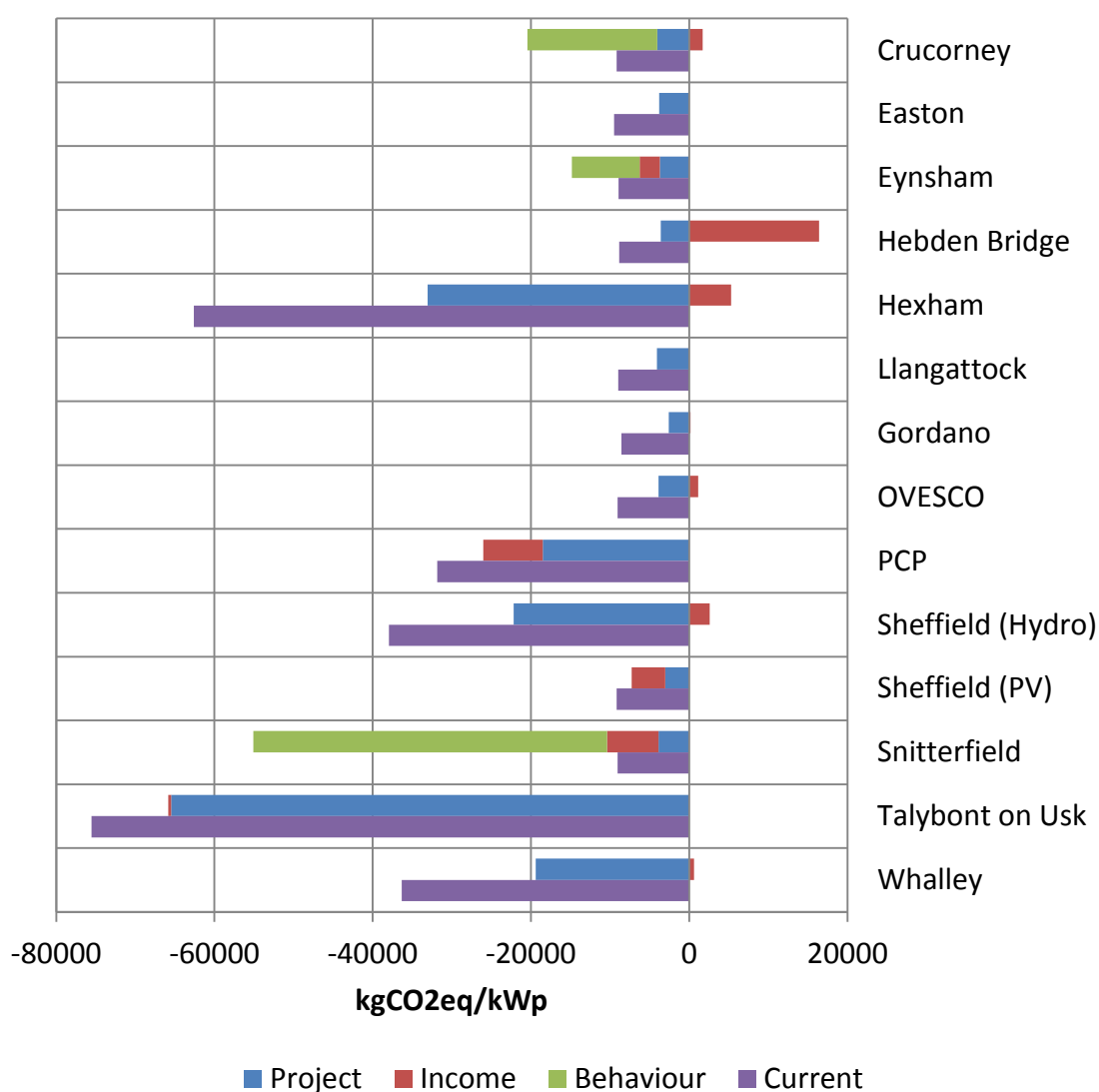


FIGURE 9-17 TOTAL CARBON FOOTPRINT OF EACH GROUP CALCULATED USING LCA METHODOLOGY COMPARED TO THE CARBON FOOTPRINT CALCULATED USING CURRENT METHODS

THE CARBON SAVING POTENTIAL OF COMMUNITY RENEWABLE ENERGY IN THE UK

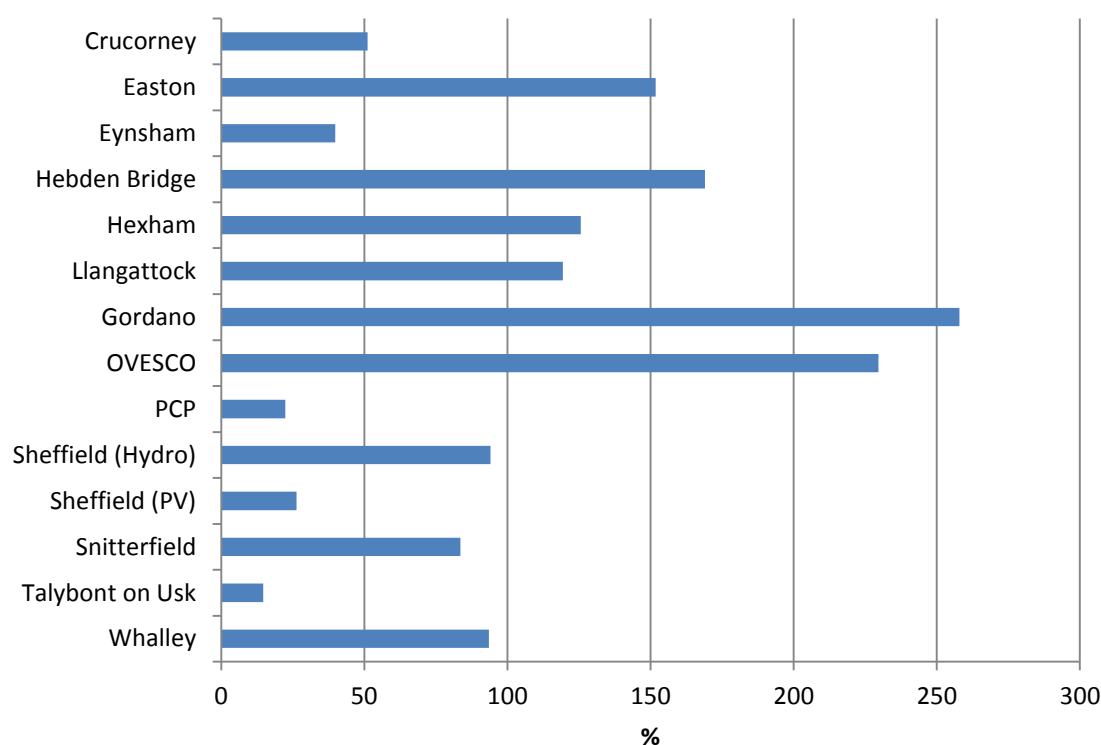


FIGURE 9-18 THE PERCENTAGE ERROR IN THE CARBON FOOTPRINT CALCULATED USING CURRENT METHODS COMPARED TO LCA METHODOLOGY

It underestimates carbon savings for the remaining community energy projects. The community energy projects for which the current method underestimates the carbon savings have a large contribution from behaviour.

Figure 9-18 shows the percentage error between the two methods of calculation (it has been assumed that the LCA methodology is more accurate than the current methodology). The range is 15% - 260% with a mean of 110%. This suggests that the current methodology is not a full representation of the carbon saving potential of community energy projects.

9.4 Summary

Typically community energy projects do lead to a reduction in carbon emissions. However the reduction in carbon emissions is generally overestimated using the current methodology. This is due to assumptions about the carbon intensity of grid electricity and the effect of including embodied carbon.

Including the wider benefit of income has a variable effect on the carbon footprint as income can both lead to an increase and a decrease in carbon emissions. However income is typically only a small proportion of the carbon footprint.

Where it is known that community energy projects have led to an increase in the amount of PV installations in the local area this has increased the carbon saving potential of the community energy project significantly. It has had a larger influence on the carbon footprint than the project itself.

CHAPTER 10 GROWTH OF COMMUNITY ENERGY

This chapter examines the current scale of community energy in England and Wales through the central feed-in tariff database. The growth of the sector is evaluated alongside an evaluation of the effect the feed-in tariff has had. Finally the potential carbon saving from the community energy projects currently installed in England and Wales is evaluated.

10.1 Community energy sector growth

The precise scale of the community energy sector is not currently known as it is a young rapidly evolving sector (DECC, 2014e). However it is estimated that 720 community groups, since 2008, have either considered or delivered a project to generate renewable energy (DECC, 2014e). However evidence from the community groups that participated in this work suggests that some groups deliver multiple projects to generate renewable energy whereas other groups do not deliver their considered project. Undelivered projects clearly cannot lead to carbon reductions through the project itself or associated income. They may have some impact on behaviour, but there is no evidence for this. It has therefore been assumed that only delivered projects will deliver carbon reductions.

Therefore the scale of uptake of community energy projects will be estimated through evaluation of the central feed-in tariff database (September 2014 version). A new section on the central feed-in tariff database was added for projects installed on or after the 1st December 2012 where projects could be specified as either community energy or school. Only 11 projects have been specified as community energy projects since this section was added until September 2014. If this is accurate it would indicate limited uptake of community energy projects since the data for this research was collected. However as this section has not been completed for most of the entries in the database it is possible that this data has simply not been filled in. Therefore for the following analysis it has been assumed that all projects defined as “community” under the original section where installation type was defined meet the definition of community energy projects used in this work and that projects defined as “domestic”, “non domestic (commercial)” and “non domestic (industrial)” do not.

Figure 10-1 shows the total number of community installations per year that have been added to the central feed-in tariff database. The vertical dashed line in 2010 represents the year in which the feed-in tariff was introduced. Some existing projects were eligible to register for the feed-in tariff scheme and consequently projects installed prior to 2010 appear on the graph.

From 1999 onwards the number of installations per year increases. The rate of increase also increases up to the introduction of the feed-in tariff. For this section, the shape of the graph is similar to graphs which describe technology uptake. The two years following the introduction of the feed-in tariff the number of installations increased dramatically. Then the number of installations per year decreases over the next two years – although it should be noted that the last year only represents the first 9 months of the year.

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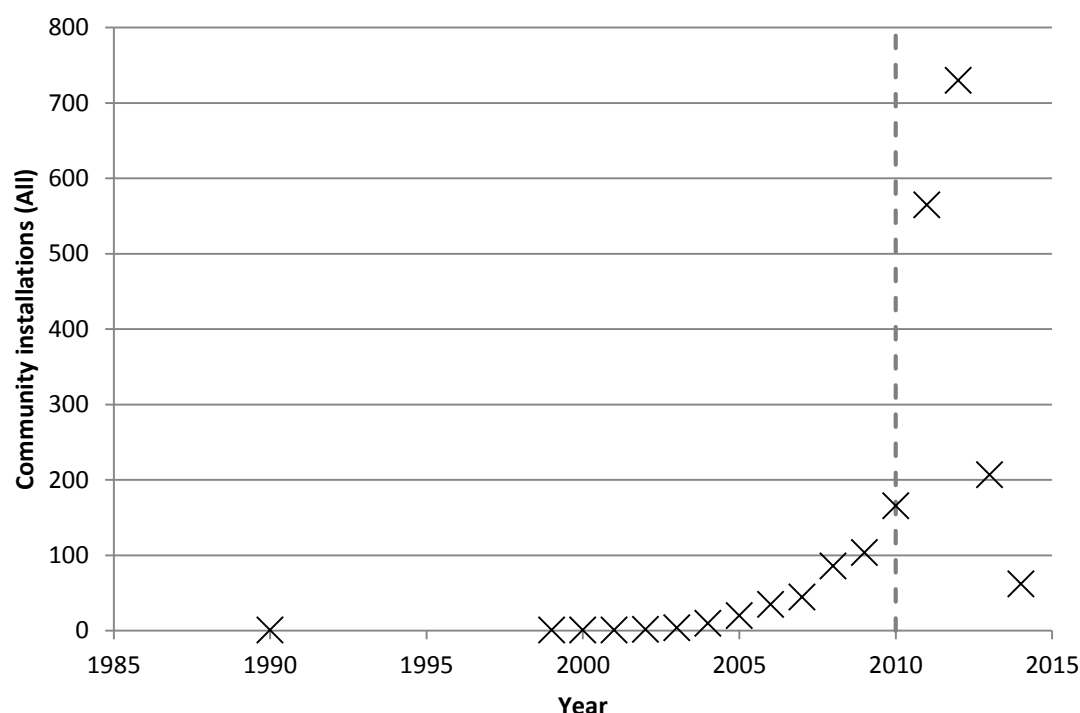


FIGURE 10-1 TOTAL NUMBER OF COMMUNITY INSTALLATIONS BY YEAR | DASHED LINE SHOWS YEAR FIT INTRODUCED, DATA FROM CENTRAL FEED-IN TARIFF DATABASE

The number of community installations by year for PV, wind and hydro are shown in Figure 10-2 to Figure 10-4. The trend of PV installations shown in Figure 10-2, matches that of the overall trend. This is because the majority of community installations are PV systems. The trend of wind installations shown in Figure 10-3 is initially similar to that of PV and the overall trend. From 2009 the number of installations decreases each year, apart from a slight rise in 2010 - the year the feed-in tariff was introduced. However the number of installations per year is low; the highest number per year is 16 in 2008. The number of hydro installations is low as shown in Figure 10-4. After one installation in 1990, the next installation was in 2005. The highest number per year was 3 in both 2007 and 2012. There was one community micro CHP installation in 2010.

GROWTH OF COMMUNITY ENERGY

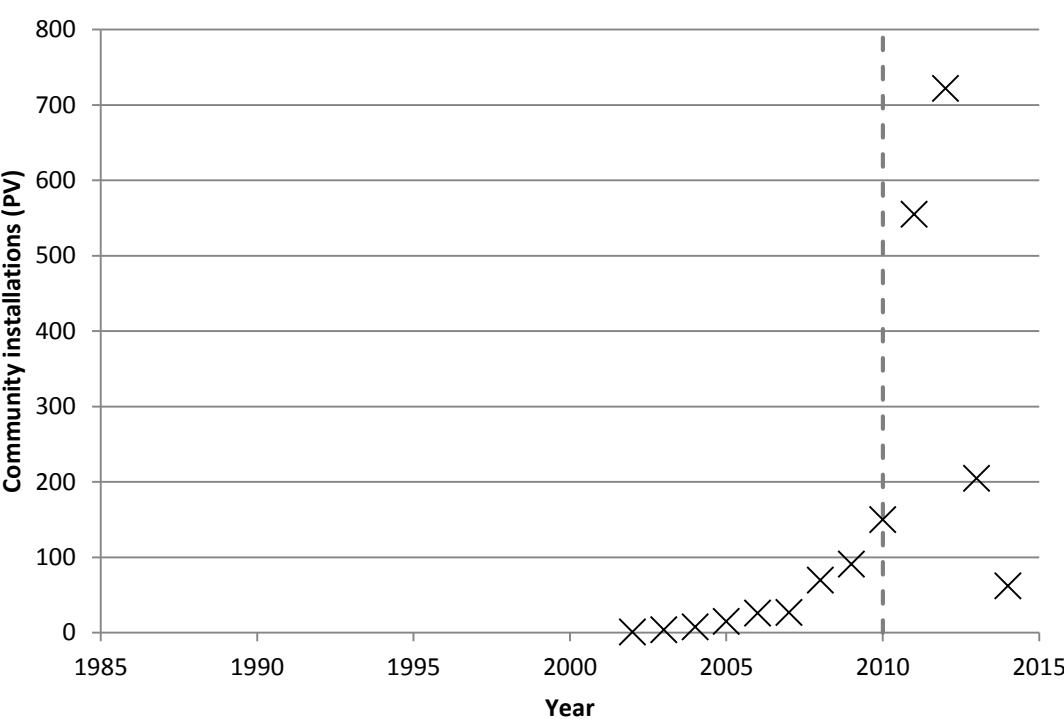


FIGURE 10-2 NUMBER OF PV COMMUNITY INSTALLATIONS BY YEAR | DASHED LINE SHOWS YEAR FIT INTRODUCED, DATA FROM CENTRAL FEED-IN TARIFF DATABASE

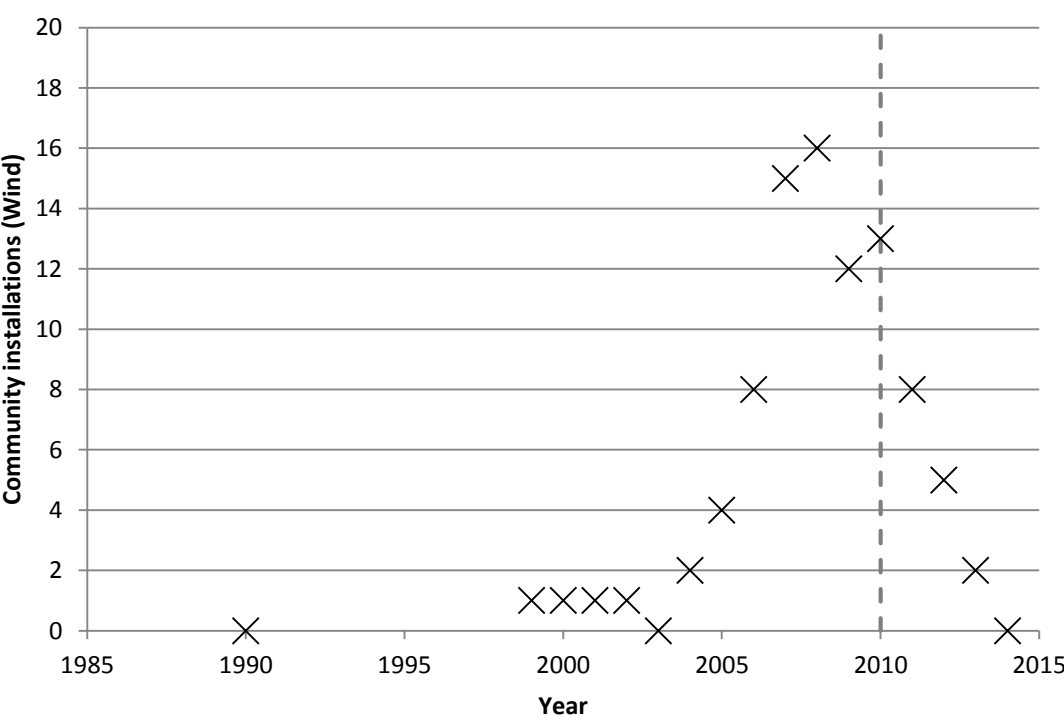


FIGURE 10-3 NUMBER OF WIND COMMUNITY INSTALLATIONS BY YEAR | DASHED LINE SHOWS YEAR FIT INTRODUCED, DATA FROM CENTRAL FEED-IN TARIFF DATABASE

THE CARBON SAVING POTENTIAL OF COMMUNITY RENEWABLE ENERGY IN THE UK

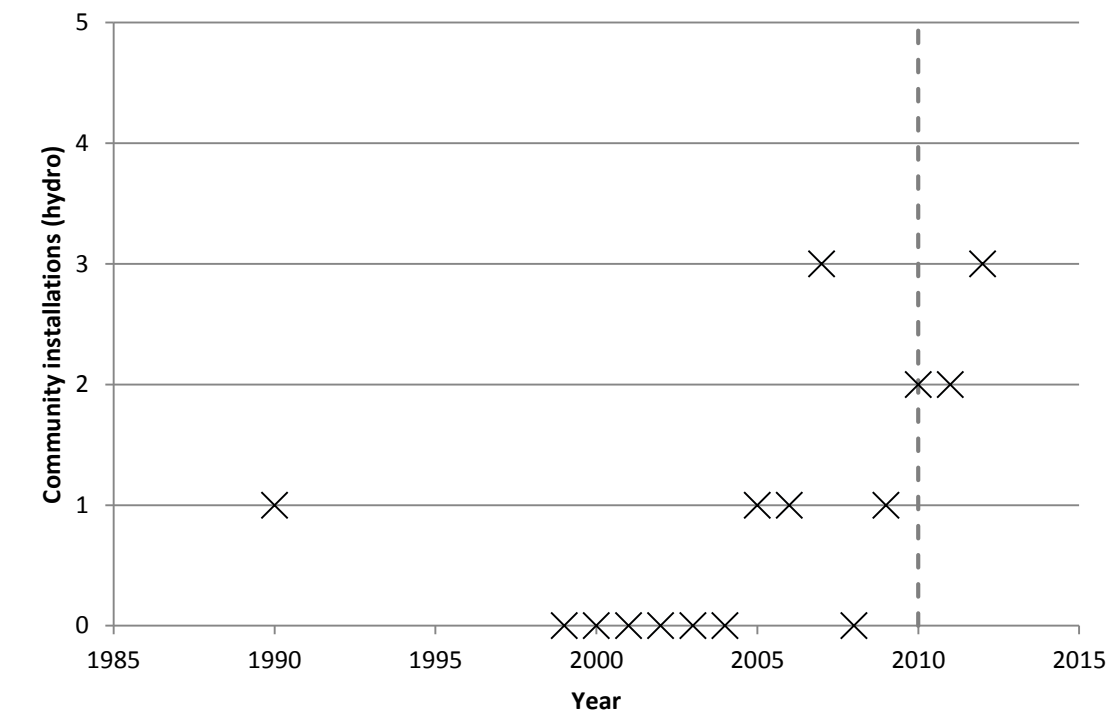


FIGURE 10-4 NUMBER OF HYDRO COMMUNITY INSTALLATIONS BY YEAR | DASHED LINE SHOWS YEAR FIT INTRODUCED, DATA FROM CENTRAL FEED-IN TARIFF DATABASE

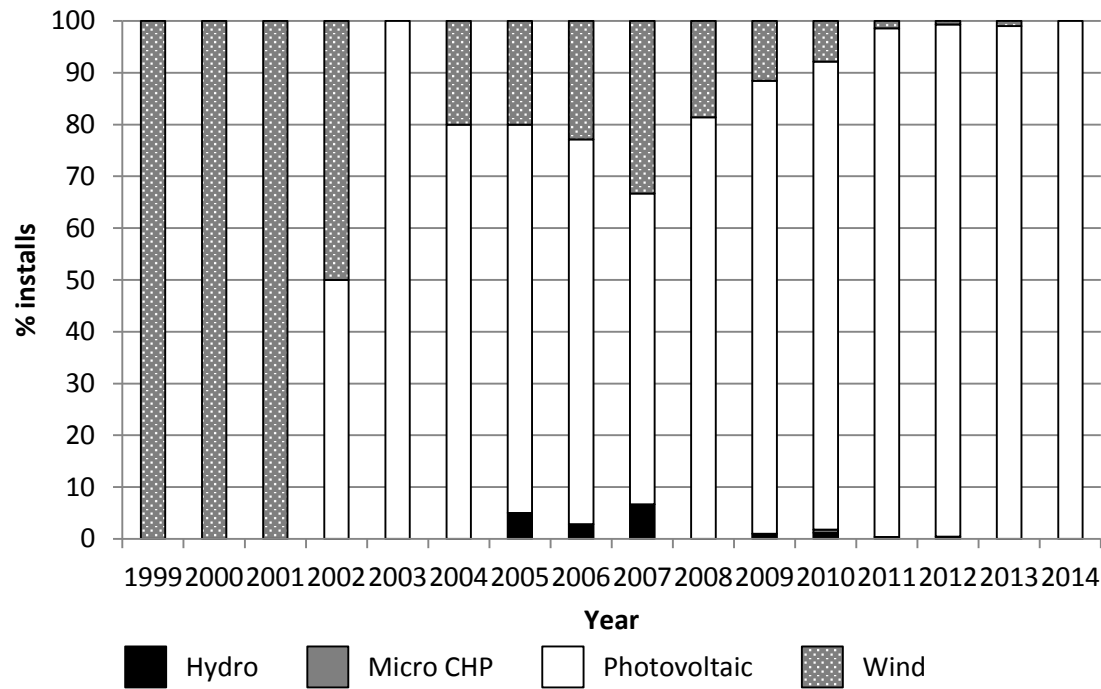


FIGURE 10-5 PROPORTION OF EACH TECHNOLOGY TYPE INSTALLED AS COMMUNITY INSTALLATIONS PER YEAR

The technology types that make up the total number of community installations each year according to the feed-in tariff database is shown in Figure 10-5. For the first three years shown on the graph the only technology installed is wind. As can be seen from Figure 10-3 this equates to one wind installation each year. The first installation of PV occurs in 2002 and from this point onwards PV accounts for the majority of installations each year. The year after the feed-in tariff was introduced the combined installations of other technology types fell to around 1%. This is mostly due to the large increase in PV installations.

Table 10-1 shows the overall proportion of different technology types installed between 1990 and September 2014 for three different samples. The first sample includes all installations during this time that have been registered on the feed-in tariff database. The second sample all installations described as community on the same database, over the same time period. The third sample is the installations carried out by the community groups that participated in this research that were known to have been installed by 01.12.2014. Each installation at separate sites has been counted as this is how they are counted in the feed-in tariff database. The sample compares well with the community installations apart from an over representation of hydro projects. The projects described as community on the feed-in tariff database have slightly higher proportion of installations due to wind and hydro than all projects. This may be because non-community versions of these projects are too large to be registered on the feed-in tariff database. It may also be because community groups are more likely to achieve local backing for these types of technology to go ahead. In Chapter 5 it was identified that this proportion could be even higher if several barriers are reduced or removed: anti-lobbies, statutory agencies and cost. However the availability of sites for community wind and hydro projects is likely to remain a limiting factor.

TABLE 10-1 TECHNOLOGY INSTALLED BY DIFFERENT SAMPLES

	FiT database (All) (%)	FiT database (Community) (%)	Research sample (installed 01/12/14) (%)
PV	99	95	82
Wind	0.69	4.4	5.9
Hydro	0.057	0.69	12
Micro CHP	0.094	0.049	0
Anaerobic digestion	0.020	0	0

PV accounts for the majority of installations. Therefore installation of this technology was explored in more detail to identify possible causes for the changes in the number of installations per year. Figure 10-6 shows the number of community PV installations each month between January 2007 and September 2014. Also shown on this graph is the timing of the main announcements and enforcements associated with the feed-in tariff.

There is some variation each month, but the general trend shown on the graph until October 2011, when the main small scale PV cuts were announced, is of an increasing number of installations per month. The rate of increase also increases over time. The graph does appear to show that the number of installations increases after the introduction of the feed-in tariff in October 2010. The rate of installation could also have risen due to other factors such as a reduction in cost of PV systems or the natural increase due to increased awareness of the

technology. The average time for completion of PV projects from their conception from the sample of projects studied in this work was 17 months. Community energy projects that began when the feed-in tariff was introduced would therefore be expected to complete around September 2011. At the end of October 2011 it was announced that the rate for small scale PV projects would be cut in early December 2011. There is a significant increase in the number of installations between these months; 27 projects were installed in October 2011, 116 in November 2011, 205 in December 2011 and 21 in January 2012. This data corroborates the evidence gained from the interviews that many community groups were close to completing their projects when the cuts were announced and that those with the finance available rushed to complete before the cuts were enforced. However a successful court case was brought against the government for introducing the cuts before the consultation about the feed-in tariff was due to finish; the changes were ruled to be “legally flawed” at the end of December 2011 (Vidal, 2011). The government appealed this ruling and introduced a new date, 3rd March 2012, on which the cuts would be enforced if the appeal was unsuccessful. A second, larger wave of 411 installations happened during this high risk period between February and March 2012. The following month only 24 PV installations occurred. A third, smaller peak of 128 installations occurred in July 2012. Six (35%) of the projects from the sample in this work completed in July 2012 – this was ascribed to a fall in the price of PV systems which temporarily improved the ratio between costs and returns from the feed-in tariff. The majority of these projects had been planned for some time. From March 2012 onwards the feed-in tariff rates are revised on a regular basis to ensure that the rate of return from the feed-in tariff is not too high. The number of new community installations has been in decline since July 2012.

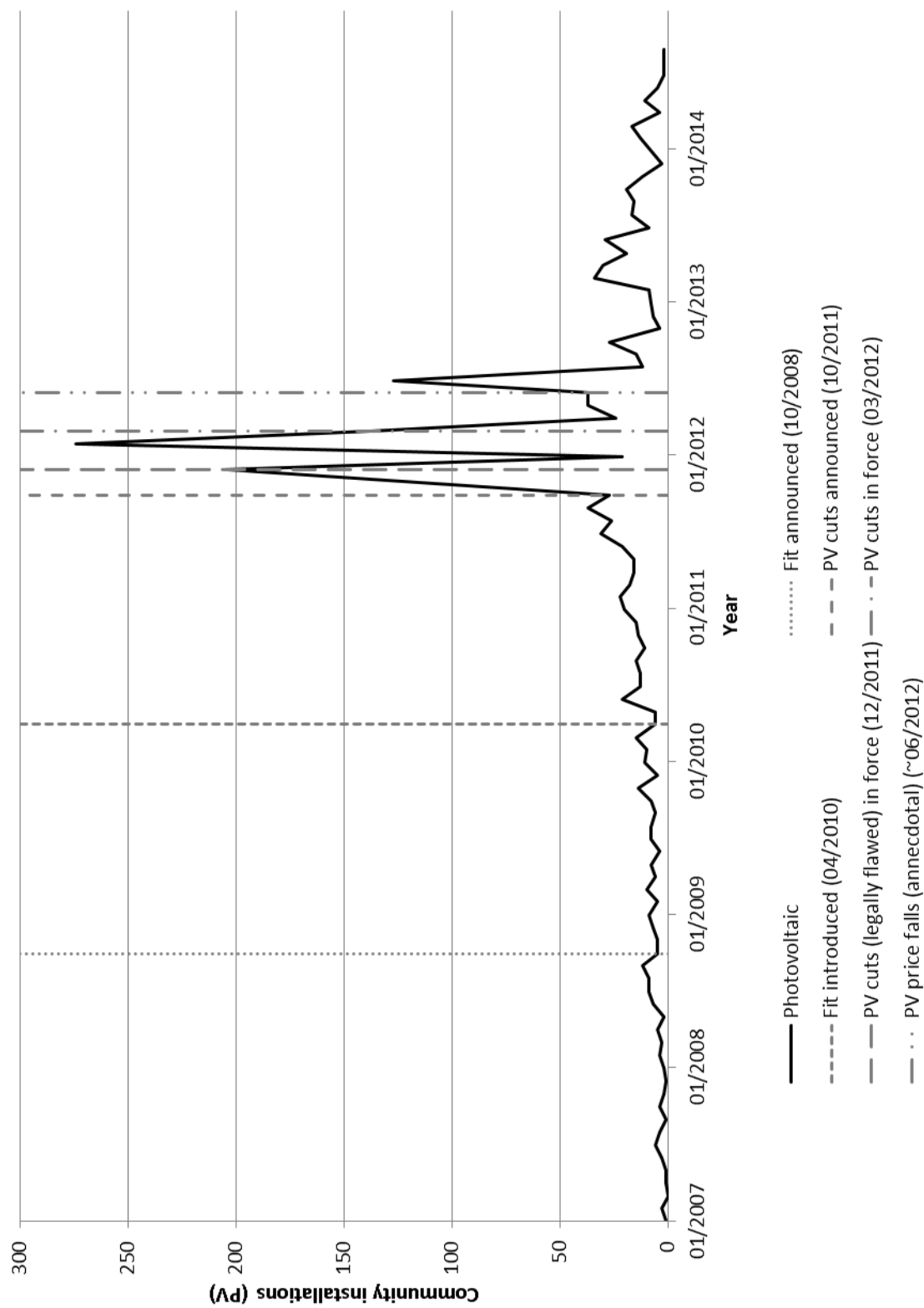


FIGURE 10-6 NUMBER OF PV COMMUNITY INSTALLATIONS BY MONTH

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The cumulative count of unique feed-in tariff IDs for both community only and all projects is shown in Figure 10-7. The solid line shows the community installations and is associated with the left hand axis. The dashed line shows all installations and is associated with the right hand axis. The shape of both lines can be described as s-shaped. However the plateau of community installations appears to have been reached sooner than the all installations. By September 2014 there were approximately 2,000 community installations and 500,000 installations in total. Community installations therefore are around 0.42% of all projects registered for the feed-in tariff scheme.

The cumulative installed capacity for both community only and all projects is shown in Figure 10-8. The shape of both lines is broadly the same as those shown in Figure 10-7. By September 2014 there was approximately 24MW of community installed capacity. This is 1% of all installed capacity registered for the feed-in tariff scheme in England and Wales. The disparity between the proportion of feed-in tariff IDs and the installed capacity of community energy would indicate that the average installed capacity of community installations is larger than other types of installations.

The DECC (2014) reports that there was at least 49MW of installed capacity of community energy projects generating although the actual figure was likely to be higher. This was calculated from a database, survey responses and further research. The method used in this research suggests that the installed capacity is 49% lower than this figure. 27% of this difference is due to the exclusion of projects based in Scotland or where the country was unknown. Some of the remaining difference is likely to be due to classification differences: i.e. community energy projects installed on domestic households are likely to be classified as domestic in the feed-in tariff database, community energy projects that are not solely led by the community are unlikely to be classified as community. Another reason for the difference is a small number of large scale wind community energy projects that are not eligible for the feed-in tariff.

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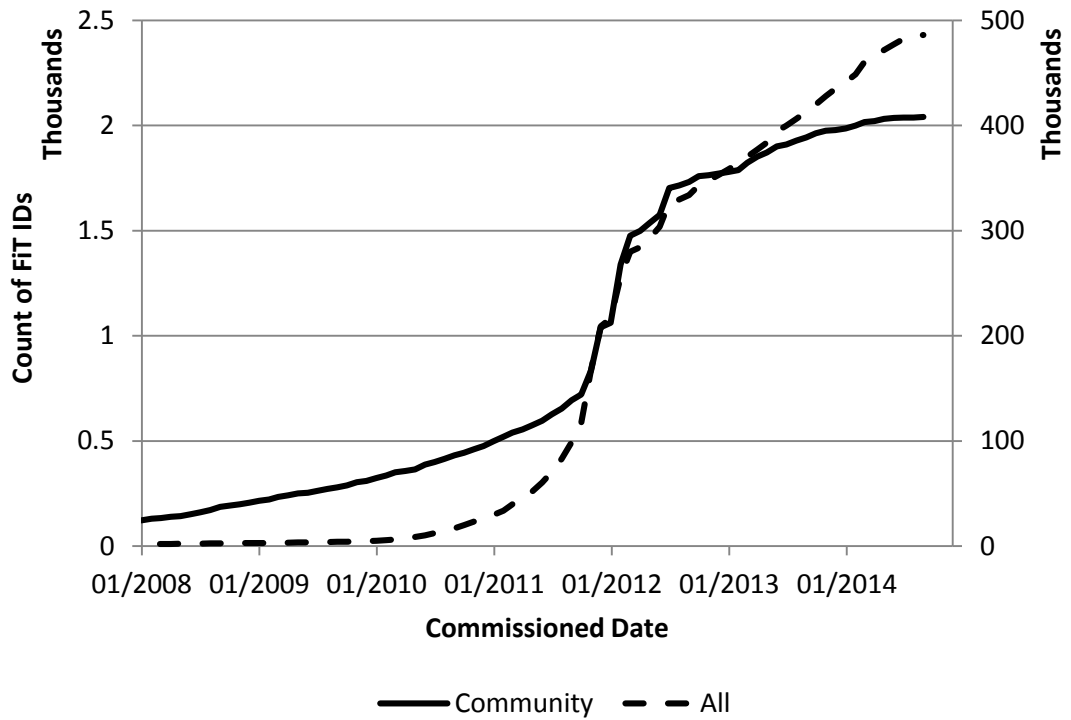


FIGURE 10-7 CUMULATIVE COUNT OF FEED-IN TARIFF IDS | COMMUNITY SHOWN ON LEFT HAND AXIS, ALL TYPES SHOWN ON RIGHT HAND AXIS

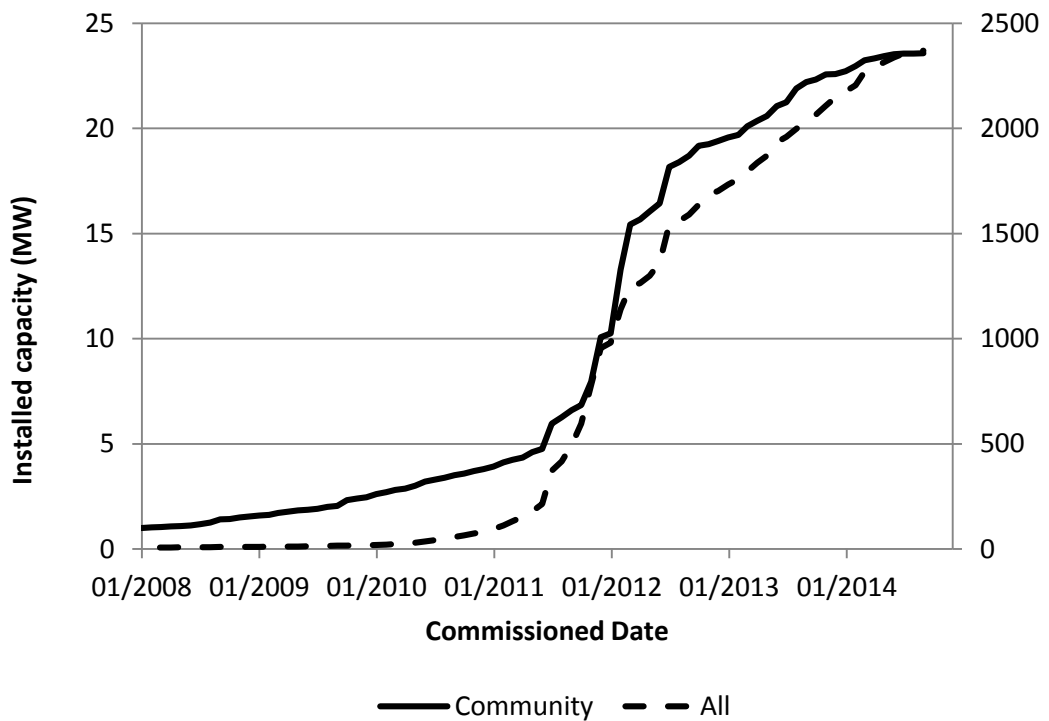


FIGURE 10-8 CUMULATIVE INSTALLED CAPACITY FROM THE FEED-IN TARIFF DATABASE | COMMUNITY SHOWN ON LEFT HAND AXIS, ALL TYPES SHOWN ON RIGHT HAND AXIS

10.1.1 Sector savings

The potential effect on carbon of the community energy projects installed between January 2008 and September 2014 is shown in Figure 10-9. This has been calculated by multiplying the installed capacity each year by the range of cumulative kgCO₂eq/kW calculated for the community energy projects that participated in this research. The vertical dashed line shows the date of the last known installation in 2014. It shows that by 2032 the community energy projects installed by 2014 are likely to have offset around 700 million kgCO₂eq.

During the same time period, according to the thousand flowers model from the Transition Pathways project the electrical grid will lead to the emission of around 3,300,000 million kgCO₂eq. The amount of carbon offset by community energy projects currently installed equates to approximately 0.02% of the carbon emitted by the electrical grid in the same time. This indicates that the community energy projects currently in existence have only a limited potential for carbon reduction viewed in the context of an 80% reduction in carbon emissions from the energy sector. However given the small number of participants in the community energy sector this should not be viewed as an insignificant contribution.

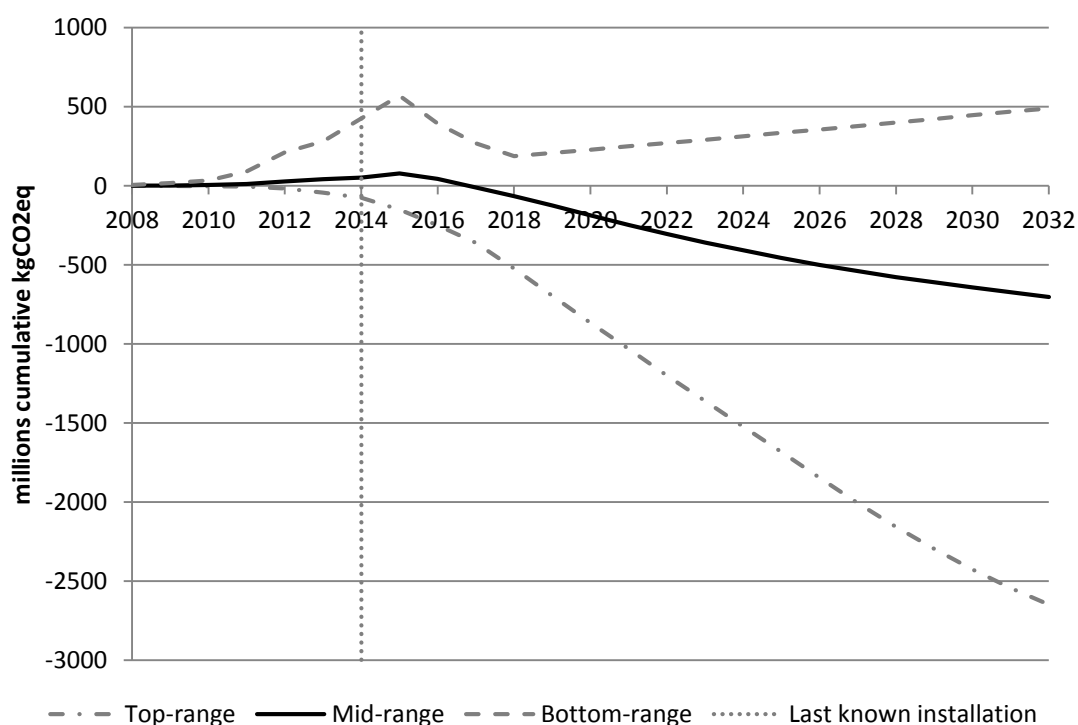


FIGURE 10-9 THE POTENTIAL EFFECT ON CARBON OF COMMUNITY PROJECTS INSTALLED BETWEEN JANUARY 2008 AND SEPTEMBER 2014

10.2 Summary

The feed-in tariff has altered the uptake of community energy projects. Its introduction appears to have increased the number of community energy projects in England and Wales. However subsequent changes to the rates which decreased the financial return of the projects, appears to have reduced the number of new community energy projects to pre feed-in tariff levels. PV accounts for the majority of community energy installations. The overall carbon saving potential of the community energy projects currently installed is approximately 0.02% of the carbon that would be emitted by the electrical grid under the Thousand Flowers Pathway.

CHAPTER 11 DISCUSSION

This chapter contains a discussion of the results of the research, which have been presented in Chapters 4 – 10. Existing literature analysed in the introduction to this work suggested that there was a need to evaluate the validity of claims made about the potential for community energy projects in the UK to reduce carbon emissions.

To this end this research was designed to answer the question: to what extent can community renewable energy projects reduce carbon emissions in the United Kingdom? The two aims of this research were:

1. To assess the net carbon emissions attributable to community energy projects in the UK and identify factors that had influenced this
2. To assess the scale of community energy in the UK

To achieve these aims, original research was undertaken based on data collected from 13 community energy groups in England and Wales. These data formed the basis of a quantitative estimate of net carbon emissions from the community energy projects. They were also used in a qualitative analysis, examining the factors that influenced community energy projects. Secondary data collected nationally was used to complement these data.

This chapter is presented in four sections. In the first section the limitations of the data and the methodology is discussed. The carbon footprint of community energy projects is discussed in the second section. The third section contains a discussion of the influence Government policy has had on the sector and on the carbon saving potential of community energy projects. In the final section is a discussion of the wider findings of this research.

11.1 Data & methodology

There is limited empirical evidence showing the impact of community energy projects. This research addresses this by providing evidence for the carbon impact of such projects both direct and indirect. There are however limitations to the data and methodology.

11.1.1 Sample and extrapolation

The complete extent and profile of community energy is by its nature difficult to define. A profile of the population of the sector was not widely available in 2011 when the research began. It was therefore not possible to select a sample that was representative of the population. When the sample was retrospectively compared to a population profile published in 2014, the makeup of the sample was found to differ slightly. However the population profile produced was not unique to community renewable energy projects and the sample includes examples covering the majority of categories measured. Additionally the majority of community energy groups that participated in this research had similar experiences and furthermore frequently referenced other groups that would also meet the inclusion criteria that had the same experiences. Therefore it is likely that the

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majority of the research results can be confidently extrapolated to other community energy projects that meet the following criteria. This list has been modified from the inclusion criteria on the basis of the findings of this research. The original inclusion criteria are shown in grey, whilst modified or additional text is shown in black.

1. Community energy project generating renewable energy or planning to generate renewable energy
2. Based in England, ~~Scotland~~ or Wales (Northern Ireland was not included as it is part of a separate energy distribution network to the rest of the UK)
3. Community of place
4. Community energy project which includes collective generation
5. Community energy projects led by a community energy group that is not principally managing a community centre

The experiences and results from the two projects included in the research where the interviewee was part of a management committee were slightly different to the majority of other projects and to each other and therefore it cannot be judged how applicable they are to the sector.

Although only communities of place participated in the research it was striking that these were frequently communities of interest (common interest of energy/climate change) based within a community of place. In the research sample, communities of place could not attract enough participants the size of the area included grew until they had reached a size sufficient to deliver a project.

It is frequently noted that one of the strengths of community energy projects is that they are bespoke to the community to which they belong, i.e. they are tailored to the needs and resources available of the community. A variety of projects were evaluated in this research with their own unique twists. However there were elements that were common to a number of groups, i.e. raising money through a share offer or community engagement through a series of meetings open to the public. Due to the networking described by interviewees it is likely that these elements will become increasingly common as community energy projects in the UK continue to develop. The sample of community energy projects could be described as innovators – mention of being “the first to...” were common in the interviews. However at the same time many of the interviewees commented that they had copied the idea from another group. For example raising a community share offer is currently the most common method of raising finance, before other avenues have been explored. Therefore unless there are any major changes to the conditions in which community energy projects operate, for example the feed-in tariff is removed and the cost of technology does not fall, the broad findings in this research are likely to apply to future community energy groups.

11.1.2 Data collection

Primary data for this research was collected principally through face-to-face semi-structured interviews with one or two representatives from the community energy group. The data therefore represents one moment in time. Particularly for groups still at the planning stage this means that the projects they have delivered are different to those discussed in the interviews. Therefore there

are slight differences between the qualitative analysis of the interviews and the quantitative analysis of the projects as the latter have largely been updated to represent the projects delivered. Many of the community energy projects had yet to start gaining or using their income at the point at which they were interviewed. Therefore some of the analysis surrounding use of income is speculative based on information given in the interview. However where possible this information was compared to what had happened since the interview.

Interviews with one or two representatives from the community energy group mean that the data only represents one or two viewpoints. Interviewees themselves suggested that even amongst the core group there were differences in opinion. Focus groups, or a series of interviews with the same community energy group would present more viewpoints, however it would have reduced the number of community energy projects analysed due to the time and cost involved in the interviews. Having a higher number of community energy projects has allowed sector wide trends to be identified.

11.1.3 Secondary data

Attempts to collect primary data from households in the community that were involved with the community energy projects were not successful. Although a few community energy groups initially seemed positive about contacting households asking them to participate, these groups then withdrew as they felt this would either not gain much interest or would annoy members. This feeling is not without some foundation. Several community energy groups had already attempted some monitoring of household energy use but had not had a high uptake and the 2014 report written for the Department of Energy and Climate Change suggested that many in the sector were facing “questionnaire fatigue”. Therefore the possibility of using publically available datasets of nationally collected data to investigate household energy behaviour change in areas with community energy projects was investigated.

The first step was to define which areas had community energy projects and which did not. This was done using the central feed-in tariff database maintained by OFGEM. However because the definition of community energy projects was only included in 2012 and has not been widely used, the research assumed that projects defined as community were the same as community energy projects. The accuracy of this assumption was checked by looking for the entries for the community energy projects that participated in the research. These projects were defined as community, but it is unlikely that all community energy projects are defined as community and that all projects defined as community are community energy project. This database would be a valuable dataset to build the evidence base about the sector if OFGEM were to require all projects, new and historic, to indicate if they met the Government definition of community energy projects.

The second step was to compare energy statistics about areas with and without community energy projects. No substantial differences between areas were apparent from an analysis of the data. It was felt this was likely because the resolution of the dataset was not fine enough compared to the small scale of community energy projects. Community energy projects typically have only a small amount of people closely involved with the project, i.e. a median of six core members and volunteers in the low tens. The smallest available resolution of the datasets covers a population of

about 1,600. Even if some community energy groups grow in scale, not all groups wanted to expand and so data collection is required at a finer resolution. This may become easier with the introduction of smart metering, however it will require the cooperation of energy suppliers to make such data available and households to allow data at this scale to be made available.

Furthermore boundaries defined by the community often do not line up with nationally defined boundaries. For example problems were caused when communities were split, with some households being eligible to participate in the Low Carbon Communities Challenge and others not. Therefore even with finer resolution data available, some input will be required from the community energy groups to define boundaries.

11.1.4 Methodology

Evaluation of the impact of community energy projects is a complex issue. The projects often do not have clearly defined boundaries, however in order to assess the impact boundaries need to be clearly defined. Therefore boundaries have been defined and applied equally and transparently to all community energy projects evaluated in this work.

A cut off point was required in order to model the projects consistently, 25 years from the point at which the idea for the project was conceived was chosen. The results should not be extrapolated beyond this point. The feed-in tariff is only guaranteed for either 25 or 20 years, therefore fairly soon after the system boundary the impact of the income will change. Additionally the technologies installed in the project, the income and behaviour all have a limited lifetime.

A life cycle assessment (LCA) of a project will more accurately represent the environmental impact than an assessment that focuses only on one phase. The results of this research show that the method currently widely in use, usually overestimates the carbon savings due to community energy projects by an average of 110%.

There are two methods of measuring the impact of renewable energy technology using life cycle assessment. The first is to calculate the embodied energy and then divide this by the amount of electricity it will produce over its life time, i.e. an attributional LCA. The other method, used in this work is to calculate the embodied energy but then to assume that the electricity produced offsets grid electricity and calculate the carbon impact of that amount of grid electricity, i.e. a consequential LCA. The attributional LCA is more transparent and will not change if the national grid changes. They are also easier to understand. However the consequential LCA in this work shows how the projects will interact with the energy system. This is more important for the sector and policy makers to understand. The consequential LCA has been made more transparent by referencing all the background data used.

The life cycle assessments were mainly based on life cycle inventories taken from the Ecoinvent 3.0.1 database. This database is considered to be the most up to date and well-documented database available for Europe. In the evaluation of the income it was necessary to use data calculated using input-output methodology due to the economic basis of the evaluation. Therefore the EU27 input-output database was used, as it was the most appropriate to the scenario that was

available for the research. However this method of evaluation means that the results are applicable only to England and Wales – the countries for which the evaluation was carried out.

The figures of grid carbon intensity values used in this research are based on the annual average carbon intensity calculated for the thousand flower pathway from the Transition Pathways project. This method produces a more conservative result than methods based on the annual marginal carbon intensity (see Appendix F for a copy of a conference paper using marginal carbon intensity). Using the annual average is also reflective of the current Government stance on calculating the grid carbon intensity.

The pathways were designed to provide the required reduction in grid carbon intensity required to meet the Government's 2050 carbon target, i.e. they are not a prediction of how the grid carbon intensity will change. However it is unlikely that the grid mix and therefore grid carbon intensity will remain constant over the time period modelled and that the changes can be predicted with any accuracy due to the complexity of the system being modelled. These scenarios therefore represent a potential future system. The results from using these figures, whilst they may over or underestimate the carbon reductions due to community energy projects, highlight that the potential of community energy projects to save carbon is highly likely to change over time. Therefore the average results presented in this research are most valid for projects already installed and installed within the next few years. Over time this analysis should be re-done to revalidate that community energy projects reduce carbon emissions. This is particularly important for PV systems, which have a longer carbon payback period as their manufacture is an energy intensive process. There is the potential that if the carbon intensity of the UK electricity falls faster than the carbon intensity of the electricity in the country of PV manufacture that this payback period will become longer and reduce the effectiveness of community energy projects, potentially to the point of increasing carbon emissions.

As a consequence of this research, a workshop was organised by the researcher to engage a number of different community energy stakeholders in discussion around the benefits of community energy projects and how these benefits could be measured. Issues around data collection and evaluation were a recurring theme during the event. There was tension about who has the responsibility for collecting and evaluating data about community energy projects between community energy groups, Local Authorities and the Government. For example Local Authorities felt that community energy groups should provide evidence that the projects created jobs before they gave them support, however community energy groups felt that Local Authorities should provide the tools for evaluating this before they could provide the evidence. It is apparent that third parties, i.e. researchers, can aid this tension as they are more able to carry out analysis and can work with community energy groups more easily to collect the data (Stow et al., 2014).

The methodology for calculating the carbon footprints of the community energy projects presented in this work could be applied to any community energy project in the UK as long as the feed-in tariff remains. Therefore the methodology could be developed into an easy to use tool with sufficient funding (as some of the background data is proprietary).

11.2 Net carbon emissions

It has been postulated that community energy projects reduce carbon emissions both directly and indirectly. This research only partially supports this statement. Community energy projects do currently reduce carbon emissions directly through the project itself. If community energy projects do cause households to install renewable energy technology this also currently reduces carbon emissions, usually far surpassing the reduction in carbon emissions from the project. However further work is required to confirm that community energy projects can lead to this behaviour. Importantly however is the finding that the majority of income from the project is frequently not used in a way that would directly reduce carbon emissions and the model suggests that some uses of income can reverse the effect of the community energy project, i.e. lead to a net release of carbon.

Gaining an income stream has become a central aim of community energy projects since the introduction of the feed-in tariff in 2010. Some community energy groups have chosen to fund activities to further reduce carbon emissions, i.e. installing energy efficiency measures. Other groups have chosen to fund other activities that support their community but that don't reduce carbon emissions. There is nothing wrong with either of these options; as stated in the summary in Chapter 2 community energy projects may have a number of benefits, this research focuses on those related to carbon. However it is important to recognise that they will have different outcomes with regards to carbon emissions and may change the overall carbon outcome of the community energy project, as shown by the models in this work. Therefore it should not be assumed that community energy projects will reduce carbon either indirectly or overall. The bulk of money for community benefit funds created from projects that were funded by community share offers is delayed until around year 10 of generation. This will limit the potential of community benefit funds used for energy efficiency measures or additional energy generation as installing such measures earlier saves more carbon in the context of a 2050 carbon target and reduction in the carbon intensity of the grid.

Additionally to this some groups are struggling to spend the income in the community in a way that they consider to be fair. This appears to have arisen because of different approaches to the concept of fairness; whether the outcome or the process is equal, i.e. energy justice (Walker, 2010).

However, for the majority of projects an increase in carbon emission from the income is small compared to the reduction in carbon emissions from the project. Consequently overall the majority of community energy projects lead to a reduction in carbon emissions, although this is not true of all such projects. Therefore share offers should not be seen as increasing carbon emissions as they have enabled many projects that would not otherwise have been built to complete. However this research suggests that alternative methods of raising finance (i.e. where appropriate teaming up with an installer to acquire free materials for community buildings) should be promoted through the "One Stop Shop" for community energy that has been commissioned by the Government under the Community Energy Strategy (DECC, 2014).

This research highlights that although projects can look very similar on the surface, the proportion of contribution from the three areas studied (project, income and behaviour), is highly variable. The

contribution from the project ranges from 7% to 100%, income from 0% to 82% and where modelled, behaviour from 58% to 81%. The range of carbon emissions due to the community energy projects over 25 years modelled in this research was between 13 tonnes CO₂eq/kW and -66 tonnes CO₂eq/kW; a range of 79 tonnes CO₂eq/kW.

11.3 Policy implications

Although community energy projects initially come about because of perceived inertia from the Government, there is little doubt that Government policy has influenced the sector.

11.3.1 Project scale and technology choice

Prior to the introduction of the feed-in tariff, the majority of community renewable energy projects appear to have installed technologies such as wind, hydro and biomass district heating at a mid-range scale. For example a community energy project, Westmill Wind Farm Co-operative, installed 6.5MW of wind turbines in 2008, compared with a private venture, Braes of Doune, that installed 72MW of wind turbines in 2007. Domestic wind turbines are typically in the tens of kW range.

Since the introduction of the feed-in tariff, the majority of community energy projects have installed PV. Typically these projects have been small. The mode of projects installed in the sample is 3.6kW and the median is 9.8kW. These projects are a similar scale to those installed domestically and are significantly smaller than commercial solar farm projects (although similar to commercial “rent a roof” schemes). The size has largely been dictated through the feed-in tariff banding structure, i.e. smaller projects receive a higher financial return. Smaller projects typically reduce carbon emissions by a smaller amount than larger projects and therefore the feed-in tariff has acted to reduce the potential of the projects to reduce carbon. Smaller projects also have implications for the on-going sustainability of the projects; a higher income can be used to employ someone to maintain the momentum of community energy groups – typically groups with volunteers only have struggled to keep delivering projects. However there is an argument that a large number of smaller, one off projects has the potential to increase the overall potential of community energy projects to reduce carbon emissions. The number of people closely involved with the project appears to be independent of the project size and the area the community energy group covers. Theoretically, a larger number of smaller projects would result in a larger amount of behaviour change than a small number of large projects. Since behaviour change has the potential to have a larger effect than the project, the overall potential to reduce carbon emissions could be increased. However this may not be possible to achieve in practice due to the need to achieve a sustainable size of the core group for project delivery, potentially by expanding the boundary of the community group.

11.3.2 Household behaviour change

Many groups had found it difficult to attract new faces to participate until they had promoted the financial benefits of installing PV systems on households. They then aimed to “green-wash” (Interviewee 11A) these people, but there is no evidence that this was achieved. The rate of domestic PV installation has decreased as the financial return has decreased, suggesting that financial benefit or at least the perception of financial benefit is required to create the potential for installation. Community energy projects have encouraged individuals to meet this potential.

The level of interest in community energy projects has changed overtime. Community groups report that interest is initially high, then decreases over time until the project is installed when it peaked

again. Evidence from other countries such as Denmark suggests that this interest will drop off again over time.

11.3.3 Limitations to growth of community energy

The community energy sector in England and Wales has experienced rapid growth in recent years although it still currently accounts for a very small proportion of energy generation. It is highly likely this growth has been driven by the introduction of the feed-in tariff. Growth in the sector can take place in two ways: existing community groups deliver more projects or new community groups form and deliver projects. However there is evidence that the number of new installations between 2012 and 2014 was substantially smaller than between 2010 and 2012. This research suggests several factors that could limit the growth of community energy.

Although the aims of community energy groups were fairly consistent, not all community energy groups planned to deliver multiple projects. This limits the potential for existing groups to deliver future projects.

Volunteers are central to the growth in community energy projects. Projects may have benefitted due to the recent recession as professionals find themselves without a job but still with the energy to do a job. However groups have struggled to maintain enough committed volunteers to reduce volunteer “burn out”. Core groups are on average 6 individuals and the next level of involvement generally contains around 20 individuals. This small structure isn’t necessarily because groups can’t recruit enough people – groups may have had many offers of help but are typically unable to benefit from them due to a lack of organisational structure to manage low level volunteers. This may hamper future growth of the sector. It is likely that volunteer burn out following the rush to install before the 2012 feed-in tariff cuts, experienced by some groups in the study, will have played a part in the two year low of new community energy installs. However due to the physical nature of the project it is likely that new volunteers will have to be found to take over management of the project. These volunteers may in time start a project of their own.

Introduction of the feed-in tariff made projects financially viable. Individuals that were already open to the ideas of renewable energy technology, climate change and community action undertook these projects. The population of the UK is still largely unaware of community energy projects, however the feed-in tariff is already reducing meaning that new projects will not be as financially attractive unless new models for delivery are created. This is likely to limit the potential future growth of the sector as those not involved currently are less likely to deliver such projects without the financial incentives. This echoes trends in other countries, such as Denmark, where growth of community energy was driven by financial incentives. When these financial incentives were withdrawn community energy went into decline.

11.4 Wider implications

This section contains a discussion of some of the wider implications of community energy projects.

11.4.1 Acceptance

It is claimed that community energy projects could increase acceptance of renewable energy technologies sited in the area. However this research suggests that this is unlikely to happen without external support. An examination of technology choice illustrated that although community energy groups were full of individuals keen to install controversial technologies such as wind and hydropower, they were avoiding doing so because they feared any project would not be successful due to the low acceptance of such technologies. Community energy groups that had attempted such projects had found they were faced with a powerful national anti-lobby with no support from powerful national pro-lobbies. Community energy groups are more likely to install wind and hydro power if they are able to access advice and financial support to combat opposition and if the financial viability of PV is much reduced (PV systems are typically much easier to install). However it should be noted that not all installations of such technologies had improved acceptance in the area, indeed issues with noise on several projects has been felt to increase negative feelings about such technologies.

11.4.2 Funding

The type of funding used to finance projects has shifted. Initially projects received partial or full grants and received an income from selling electricity to suppliers. However currently projects are typically financed through community share offers and receive an income from the feed-in tariff. This is partially because the number of grants has decreased and the number of applicants increased and partially because EU state aid regulations means that technology funded by public grants is not eligible to receive the feed-in tariff. Although the move to community share offers is a more sustainable financing option than grant funding, it has reduced the potential of the income stream to reduce carbon emissions or be spent for community benefit as the majority is paid back to the shareholders. Community energy groups frequently identified that they lacked financial skills in the core group. A national bank of financial advisors for community energy projects may help to maximise the finance available for community benefit.

11.4.3 Employment & skills

There is a perception amongst community energy groups that Local Authorities should support community energy projects that, for example, help to reduce the number of hospital visits due to a reduction in fuel poverty. However Local Authorities do not control the health care budget. Of more importance to Local Authorities in England are unemployment figures and job creation. Job creation is frequently quoted as one of the wider benefits of community energy projects. However to date

there has been little evidence that community energy projects do or do not create jobs. Consequently many Local Authorities appear reluctant to support community energy projects⁹.

There are several types of job that community energy projects could create. The first is directly; jobs created to work on an ongoing basis for the community energy project. The next is jobs created on a one off basis, for example the installer of the technology. The final type is indirect job creation. For example, it has been argued that shareholders in community energy projects are likely to spend the additional income they gain in the local community, helping to support local shops.

Of the final type of job creation this research offers little insight, other than casual comments from a few shareholders to suggest that they invested to save money for a specific purpose rather than any plans to use the income generally in the local community.

Community energy groups do typically appear to support local businesses directly by offering them contracts for supply and installation of renewable energy technology. However due to time taken to implement a community energy project and the way in which the majority of projects are managed, i.e. projects take between 6 months and 4 years and non-concurrently, this source of work alone would not support a business. Some community energy groups planned to use the income to install energy efficiency measures on an on-going basis. It is likely that these groups would use local businesses where available. Although this work would be more regular than technology installs, the analysis in this research suggests that even this is unlikely to be a sustainable source of support. The amount of money available for these measures is initially very small and then rises rapidly towards the end of the time period modelled, the income from the feed-in tariff ends a few years after the time period modelled for most projects; i.e. a boom and bust situation.

A minority of groups either do or have plans to create employment directly. These jobs are typically low salary, part time jobs. Jobs that have been created have generally been part of a large grant given to the group, for example to run a local energy advice service. The financial situation of many of the groups modelled in this research suggests that they will be unable to continuously create a part time, low salary job on income from the feed-in tariff for one project until around year 10 of the project. There appear to be broadly two types of jobs that have been created: project manager and communications officer. Either someone with project management skills or someone from within the group has usually filled the first of these jobs. This type of job is often paid part time but the amount of work makes it a full time job. Someone outside of the core group has usually filled the second type of job, however this job is usually a few hours a week. A third type of job has been suggested in some of the interviews for hydro projects – someone is needed to clean the filters every day. Although community energy projects rely on volunteers, indeed being run by volunteers is considered one of the strengths of community energy, there was a general feeling that jobs that

⁹ Finding from a stakeholder workshop held as part of the research project to discuss benefits of community energy and how to provide evidence of these benefits. This workshop was attended by a mix of stakeholders, including representatives from several local authorities. The report of this workshop is available online

<https://wiki.bath.ac.uk/display/ser/Community+Energy%3A+assessing+the+benefits>

needed to be done regularly should not be left to volunteers. However there is no evidence that any of these types of job have been created.

This situation may change for community energy groups that continue to deliver projects as some groups are doing as they will have a larger income with which to provide employment. However it has also been speculated by a number of groups that they would be able to grow more quickly if they were able to employ someone. The sector may therefore benefit if core rather than project funding were more accessible.

Upskilling of volunteers is also quoted as a benefit of community energy projects. Interviewees often referred to the things that they had learned through the project. However the majority of volunteers that the community energy groups that participated in this research were already retired; these projects are typically not improving the skills of the national workforce. There are some good examples of project installations being used to train young people, i.e. Brixton Energy projects. However in this example training is one of the central aims of the projects.

CHAPTER 12 CONCLUSIONS

This chapter contains the conclusions drawn from the research presented in this work. This research aimed to answer the question: what is the potential of community renewable energy projects to reduce carbon emissions in the United Kingdom (UK)?

The conclusions are presented in four sections. The first section summarises the research against the research objectives set out in the introduction. The second section sets out the key findings from the research. The third section discusses the contribution this research makes to the community energy sector. The final section contains a list of areas of further work based on the research presented in this thesis.

12.1 Research objectives and research outcomes

1. *Recruit and collect data from community energy groups that have installed or are planning to install renewable energy generation as part of a community energy project*

13 community energy groups that had or were planning to install renewable energy generation were recruited to participate in the research. Data was collected from all these groups during a face-to-face, semi-structured interview during 2012-2013. The profile of the sample of community energy groups was compared to a sector profile created for the Department of Energy and Climate Change in 2014. Although the sample profile taken in 2011 was not an exact match to the sector profile made in 2014, the sample did contain examples of most categories.

2. *Examine why certain courses of action are taken during delivery of a community energy project*

Thematic analysis was used to qualitatively analyse the interviews. Analysis reveals that the community energy groups had similar experiences and had made similar decisions despite having different characteristics. The impact of national and local governance and other statutory agencies on the sector should not be disregarded, i.e. the feed-in tariff has both affected the size of community energy projects and their viability and has shifted the focus from environmental to creation of an income stream.

3. *Investigate the extent to which decisions during project development have affected the carbon footprint of the project*

A series of life cycle assessments were created to examine the effect that installed capacity, choice of installed technology and the country of origin for PV systems had on the carbon saving potential of the community energy projects. These three aspects were identified during the thematic analysis as factors that the community energy group influenced through the decisions that they made. It was found that the installed capacity of a project had little effect on the carbon reduction of the project per kW installed. Although all

projects, regardless of technology reduce carbon emissions, wind and hydro projects save more than the equivalent installed capacity of PV. The country of origin for PV systems had only a minor effect on the carbon reduction of the project; however this may change in the future as grid mixes in different countries change.

4. Investigate the potential carbon emission impact due to the income generated by the community energy project

The carbon emission impact due to use of the income from the community energy project was calculated for each community energy group that participated in the research. The carbon emission impact was estimated by first calculating how much money would be generated and spent. This was then translated into carbon emission impacts using existing LCA taken from databases. This analysis reveals that it should not be assumed that the income will be used to further reduce carbon emissions. For example a large portion of the income, up to 80%, from community energy projects funded through community share offers, as the majority now are, is used to pay interest and return capital to shareholders. By undertaking a temporal analysis of the cash flows and subsequent carbon emissions, it was revealed that paying back shareholders limits the income available for carbon reduction measures prior to year 10 of the community energy project. This reduces the ability of income reinvestment to reduce carbon emission in the context of a 2050 carbon target.

5. Investigate the extent that community energy projects influence energy use and installation of renewable energy systems by households within the community

Two sources of data, a national dataset compiled for this research and household energy use collected by one community energy group, were evaluated using quantitative statistical techniques. More research is suggested to evaluate the extent of behaviour change in communities. Modelling of anecdotal evidence gathered from the interviews suggests that household behaviour change has the potential to have a larger impact than the original project.

6. Calculate the carbon footprint of the recruited community energy projects including the wider carbon emissions attributable to the project, using life cycle assessment (LCA) methodology

Life cycle assessment methodology was used to calculate the carbon footprint of each project of the community energy groups that participated. Three aspects were included: the project, the income and energy behaviour of households in the community. The footprint was modelled temporally over a 25 year period beginning from the start of the idea. The majority of community energy projects that participated in the research led to a reduction in carbon emissions by the end of the time period modelled; the average carbon payback period of these projects is 5 years. One project did not payback the carbon during the period modelled as the income stream was used to heat the community building. This use of income should not be viewed negatively in the wider realm of community energy

projects: i.e. a warmer building may be used more and may improve community cohesion etc. however this is not evaluated in this work.

7. *Compare carbon footprints of different community energy projects and evaluate the range of outcomes*

The carbon footprints of the community energy projects were compared, both per project and per kWh. Generally projects with larger installed capacities reduce carbon emissions further than those with smaller installed capacities. However when compared per kWh, some smaller projects reduce carbon emissions further than larger projects. This is due to a combination of the amount of electricity generated per kWh and household energy behaviour.

8. *Compare carbon footprints produced using LCA methodology with those produced using current methodology which focus on the generation phase only, to assess the validity of the current methodology as a basis for policy creation*

A value of carbon saving for each project was calculated using current methodology, i.e. multiplying the amount of energy generated by the average carbon intensity of the grid. This was then compared to the carbon footprints calculated using the methodology created for this research. If household behaviour change is not included, the current methodology overestimates carbon savings. If it is included the current methodology underestimates carbon savings.

9. *Examine the growth of community energy in the UK and the affect this will have on carbon emissions from the UK*

The central feed-in tariff database was used to estimate the growth of community renewable energy projects in England and Wales from 2008 up to September 2014. The number of community renewable energy projects increases rapidly up to 2012. Between 2012 and 2014 the number of new community energy projects appears to be in decline. The potential carbon impact of existing projects was modelled using the carbon footprint results of the community energy projects that participated in this research. This was then compared to the total amount of carbon emissions due to energy use over the same time period. Community energy projects already installed account for approximately 0.02% of carbon emissions from the grid under the conditions modelled.

12.2 Key findings

- Community energy projects to generate renewable energy do generally reduce carbon emissions in the UK. Carbon emissions are reduced directly through the electricity production of the project. Carbon emissions are also reduced indirectly through households that install renewable energy as a result of the community energy project. This source of carbon emissions has the potential to greatly increase the potential of the project to reduce carbon emissions. However use of the income stream frequently reduces the potential of the community energy project to reduce carbon emissions.
- Although the sector developed as an alternative to Government action, the impact that government policy has had on the sector should not be ignored. There is evidence that the introduction and subsequent changes to the feed-in tariff have influenced the sector and affected the potential for community renewable energy projects to reduce carbon emissions in the United Kingdom.
 - The rapid growth in community energy projects between 2010 and 2012 is likely to be due to the introduction of the feed-in tariff. However this rapid growth is mostly small scale, PV systems. Small scale systems have a smaller potential to directly offset carbon emissions and PV systems have a longer carbon payback period than the technologies that were traditionally installed by community energy groups, i.e. wind and hydro. This growth has not been sustained; the number of new community energy projects has been in decline post 2012.
 - The introduction of the feed-in tariff created the financial potential for householders to install domestic renewable energy, particularly small PV systems. Some community energy projects provided the impetus for householders to utilise this potential.
 - The income stream created by the feed-in tariff is typically reinvested in the local community, often in energy efficiencies or future projects. However a large portion of the income stream from community energy projects that were funded by a community share offer is distributed to shareholders rather than the community. Paying shareholders interest also has the effect that the majority of the income that is spent on the community is only available towards the end of the project

12.3 Research contribution

This research adds to the evidence base of the community energy sector, which was recently identified as limited in a report written for the Department of Energy and Climate Change. The work illustrates that the majority of community energy projects reduce carbon emissions in the UK when measured using LCA methodology. Only one study of the carbon saving potential of community energy projects has previously used LCA methodology, but this study did not include the impact of the income stream. Importantly this research provides novel empirical evidence of how the income stream generated by the feed-in tariff is used by community energy groups and the potential carbon impact.

12.4 Further work & recommendations

Work in the following areas would build on the research presented in this thesis:

- Use of the income stream has been identified as potentially limiting the carbon saving potential of community renewable energy in the UK. Further research should investigate the secondary effects of the income stream, for example, how do shareholders spend the income they gain from the projects?
- Household energy behaviour can substantially increase the potential carbon reduction of the community energy projects. A study focused on collecting evidence of household energy behaviour at the community level would aid quantification of the effect. Smart metering and cooperation from energy suppliers would improve the likelihood of such a study succeeding.
- Projects that generate renewable energy are only one aspect of the community energy sector. The methodology presented in this work could be applied to other types of community energy project with a small amount of modification.
- The methodology presented in this work could be developed into a tool for community energy groups to use as an aid to project development and impact assessment.

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APPENDIX A. RECRUITMENT

Recruitment email sent to community groups and a copy of the survey.

Dear Community Group,

I am undertaking a PhD at the University of Bath where I am attached to the Sustainable Energy Research Team (SERT). I am conducting research into how community groups are helping to reduce carbon emissions from the UK by changing the way in which energy is viewed and used. The University of Bath is funding my work. I am contacting you because I am currently seeking community groups who would like to be involved with the research. This involvement can be as much or as little as suits the group.

I will of course feedback my results to your group and would be happy to discuss and explain any questions you have at any stage. By being involved in the research your group will benefit by:

1. Receiving a detailed carbon footprint of your energy projects
2. Getting a document which indicates ways in which your community can improve its carbon footprint
3. Knowing that it has contributed valuable data which should influence future policy makers when considering the development of the UK's energy policy

Initially I am asking community groups if they would complete a brief survey about the group's activities. This survey should take no more than 10 minutes. This survey can be found here:

<http://www.smart-survey.co.uk/v.asp?i=57542kwwwx>

After completing this survey if your group would like to have further involvement in the research I anticipate this will involve:

- An interview to explore the activities of the group in more depth
- My monitoring of the energy use in the community and of any energy the community group generates

This information would then be used to create a carbon footprint of your community's activities.

Your group can choose to be involved as much or as little as suits the group and could of course withdraw from the research at any time if it wished.

If there is someone more appropriate in your group for me to contact, please send me their details and I will contact them instead. Additionally, if you know anyone in a different community group who may be interested in taking part in the research, please forward this email on to them or send me their details so I can contact them. I am interested in groups who are already generating power, those currently exploring the possibility of generating in the future and those exploring reduction of energy use and carbon at a local level.

If you have any queries please send me an email M.Stow@bath.ac.uk or call on 01225 385164 (standard office hours).

Thank you for your time,

Maddy Stow MEng

Contact details collected in this survey will only be used to contact the group with regards to the research project. The information will not be disclosed to any third party. The information will be kept securely and will be kept no longer than necessary.

--

Miss Maddy Stow MEng
PhD Researcher

Community Project Survey



Community Group Survey

This survey is part of a PhD research project being undertaken at the University of Bath in the Sustainable Energy Research Team (SERT). It is funded by the University of Bath.

The research is an investigation of how community groups are helping to reduce carbon emissions from the UK by changing the way in which energy is viewed and used in their community.

This survey should be answered by an individual acting on behalf of the community group.

You may withdraw from this survey at any point in time.

Contact details collected in this survey will only be used to contact the group with regards to the research project. The information will not be disclosed to any third party. The information will be kept securely and will be kept no longer than necessary.

If you have any queries please send me an email M.Stow@bath.ac.uk or call on 01225 385164

What is the name of the group?

What location does the group cover? (i.e. the town or street)

Which of the following categories most closely describes the group?

- ☐ Community interest company (CIC)
- ☐ Community support charity
- ☐ Grassroots movement
- ☐ Transition town
- ☐ Not applicable
- ☐ Other, please specify:

What activities are the group currently involved with?

Please tick all that apply

- ☐ Community gardens or orchards
- ☐ Energy use monitoring (households or community buildings)
- ☐ Generating energy
- ☐ Installing energy efficiency measures
- ☐ Providing advice or educating about energy efficiency
- ☐ Providing community space
- ☐ Swap shops
- ☐ Switching energy supplier
- ☐ Thermal imaging of heat loss
- ☐ Not applicable
- ☐ Other, please specify:

Describe how the group is generating energy

(i.e. community share wind turbine, biomass boiler in village hall)

Is the amount of energy generated monitored for any of the projects described in the above question?

- ☐ No
☐ Yes
☐ Not applicable

Is the group currently considering or in the process of developing, energy generation in the community?

- ☐ No
☐ Yes
☐ Not applicable

I am looking for communities willing to take part in further research. This would involve an interview about the activities carried out by the group, monitoring of energy use in the community and any energy the group generates. This information would be used to create a carbon footprint of the community's activities. The group can choose to be involved as much or as little as suits the group.

Would the group be willing to take part in further research?

- ☐ No
☐ Yes

If yes, please provide contact details for the group

APPENDIX B. SEMI-STRUCTURED INTERVIEW

LCA community interview

1 COMMUNITY GROUP

1.1 Describe the community group

- How did it form
- Purpose for formation
- When did it form

1.2 How many people are involved

- How many core people
- How many peripheral

1.3 Has the level of involvement changed over time

- How has it changed
- Why do you think it has changed (anything to do with the generation project)

1.4 What other activities take place in the local community to change energy

- How long have they been running
- How successful do you think they have been

2 COMMUNITY RENEWABLE ENERGY SCHEME

2.1 Why generation

- How did it come about
- Who were the main actors (did the local authority start it)
- What is the purpose

2.2 How many people are involved

- How many core people
- How many peripheral

2.3 Has the level of involvement changed over time

- How has it changed
- Why do you think it has changed (anything to do with the generation project)

2.4 Was there any local resistance to any activities your group has run

- What was it against
- What form did it take
- What proportion of the community took part
- By groups outside the community? (i.e. local authority)
- Why do you think it came about
- Did you get round it and how

2.5 Was there any local support for any activities your group has run

- What was it supporting
- What form did it take
- What proportion of the community took part
- By groups outside the community? (i.e. local authority)
- Why do you think it came about
- What did it enable you to do

2.6 What are the benefits of your project

- Who benefits – identify groups
- What benefits
- How do they benefit
- Has there been any protest about distribution of benefits
- Any examples

2.7 Any issues with obtaining planning permission

- What issues were raised and why
- How did you get round (what changes were required)
- What did you have to do to avoid problems

2.8 Any issues with policies

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- Have you benefited or suffered from any government policies
- Which ones and what did it effect
- Have changes to any policies (i.e. feed in tariff) affected your project
- How did you get round (what changes were required)
- What did you have to do to avoid problems
- What changes would make things easier for community groups

3 GENERATOR

3.1 What is the make and model of the generator installed?

3.2 What is the installed capacity in kW?

3.3 Do you monitor the energy generated?

3.3.1 *Can I have it, do you have any historical data that I can have and how can I get it?*

3.3.2 *Can I install a monitor?*

3.4 Was the generator new or second hand?

3.4.1 *If second hand, was a refit done and what did this entail, when was the generator originally built?*

3.5 Where did it come from and how was it transported?

3.6 How was the type of renewable energy technology chosen?

4 INSTALLATION

4.1 Describe the process of installing the generator

- What equipment did you use (i.e. cranes, diggers, spades)
- How long did each process take (i.e. crane for 2 days)
- Who installed (i.e. local company, generator supplier)

4.2 Did anything go wrong

5 MAINTENANCE

5.1 Describe the regular maintenance schedule

- How often is the generator checked
- Who checks the generator
- What happens

5.2 Has anything broken and needed to be replaced?

- What broken
- When did it break
- How long did it take to fix
- New parts

6 DISPOSAL

6.1 Describe how the generator will be disposed

- What will happen to it
- Will it be used until it is uneconomical to fix it
- Will it be replaced

7 TIME SCALE

7.1 When did you start generating?

7.2 How long did the project take, hold ups

7.3 When was the technology installed

8 FUNDING

8.1 How was funding obtained

- Were there any difficulties getting funding
- How did you finance the project

- 8.2 How much did the generator cost?
 - 8.3 How much did installation cost?
 - 8.4 How much does maintenance cost on average per year?
 - 8.5 How much have repairs cost?
 - 8.6 How much do you anticipate disposal will cost
 - 8.7 Any other costs
- 9 OTHER
- 9.1 I would like to monitor the energy use in the village hall, do you think that would be possible?
 - 9.2 I would also like to monitor the energy use of households that might have been affected by the community energy
 - 9.3 like to target households that may have been effected by the community energy to recruit them into my study.
 - 9.4 Is there anything else you would like to add?
 - 9.5 What questions should I have asked?
 - 9.6 Any questions you would like to ask me?

APPENDIX C. PROJECT DATA

TABLE C. 1 INVENTORY DATA FOR ROOF MOUNTED PV PROJECTS

Group	PV (kWp Photovoltaic slanted-roof installation, 3kWp, multi-Si, panel, mounted, on roof)	Invertor (kWp Invertor, 250kW)	Maintenance (litres tap water)	Energy generation (kWh Electricity)
Crucorney Energy Group	9.8	9.8	0	172,766
Easton Community Centre	18	18	0	328,680
Green TEA	16.65	16.65	0	285,593
Hebden Bridge Town Hall	4	4	0	67,960
Llangattock Green Valleys	4.23	4.23	0	72,769
OVESCO	161.5	161.5	439,039	2,808,954
Sheffield Renewables (PV)	50	50	0	881,460
Snitterfield Climate Change Actioning	10.8	10.8	0	187,502

TABLE C. 2 INVENTORY DATA FOR GROUND MOUNTED PV PROJECTS

Group	PV (kWp Photovoltaic plant, 570kWp, multi-Si, on open ground)	Invertor (kWp Invertor, 500kW)	Maintenance (litres tap water)	Energy generation (kWh Electricity)
Low Carbon Gordano	1875	1875	4,821,054	30,844,875

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TABLE C. 3 INVENTORY DATA FOR HYDRO PROJECTS

Group	Hydro (Archimedean Screw kWp)	Maintenance (kg lubricating oil)	Energy generation (kWh Electricity)
Hexham River Hydro	100	37	12,040,000
Sheffield Renewables (hydro)	80	37	5,838,333
Talybont on Usk Energy	36	45	5,228,750
Whalley River Hydro	100	41	6,986,250

TABLE C. 4 INVENTORY DATA FOR WIND PROJECTS

Group	Wind (kWp Wind power plant, 800kW, fixed parts Wind power plant, 800kW, moving parts)	Maintenance (kg lubricating oil)	Energy generation (kWh Electricity)
Pennine Community Power	10	49	612,500

TABLE C. 5 ROTOR DIAMETER OF WIND TURBINES

Capacity (kW)	Diameter (m)	Power (5m/s rate)	Height (m)	Source
10	7.5			msc
6	5.5	10168	17	msc
10	6.4	13971	17	msc
20	10.4	28095	17	msc
10	7	13800		msc
6	6.2	9920		msc
11	9	21530		msc
6	8	17000		msc
12	9	24500		msc
5	5.5	9170		msc
10	9.7			msc
6	5.6	8949		msc
15	9.8			msc
3	3.8	4700		msc
3	3.72			msc
10	7.2			msc
100	21	145000	30	http://www.capture-energy.co.uk/wind-turbines/northern-power-100kw
100	24	170000	30	http://www.capture-energy.co.uk/wind-turbines/northern-power-100kw
100	26		30	http://www.capture-energy.co.uk/wind-turbines/northern-power-100kw
100	21.5			
250	53		50	http://www.ewtdirectwind.com/wind-turbines/ewtdirectwind-turbines/dw5254-250kw.html
500	53		50	http://www.ewtdirectwind.com/wind-turbines/ewtdirectwind-turbines/dw5254-250kw.html
900	53		50	http://www.ewtdirectwind.com/wind-turbines/ewtdirectwind-turbines/dw5254-250kw.html
2000	93			http://www.ewtdirectwind.com/wind-turbines/ewtdirectwind-turbines/dw5254-250kw.html
500	33		40	http://www.windflow.co.uk/products
1500	77		70	http://geosci.uchicago.edu/~moyer/GEOS24705/Readings/GEA14954C15-MW-Broch.pdf
1500	82.5		70	http://geosci.uchicago.edu/~moyer/GEOS24705/Readings/GEA14954C15-MW-Broch.pdf
3000	100		100	http://www.acciona-energia.com/activity_areas/-wind-turbines/models.aspx
3000	109			http://www.acciona-energia.com/activity_areas/-wind-turbines/models.aspx
3000	116			http://www.acciona-energia.com/activity_areas/-wind-turbines/models.aspx
3000	125			http://www.acciona-energia.com/activity_areas/-wind-turbines/models.aspx
1500	70		80	http://www.acciona-energia.com/activity_areas/-wind-turbines/models.aspx
1500	77			http://www.acciona-energia.com/activity_areas/-wind-turbines/models.aspx

APPENDIX D. INCOME DATA

TABLE D. 1 CARBON IMPACT ASSOCIATED WITH VARIOUS ENERGY EFFICIENCY MEASURES FOR DOMESTIC HOUSEHOLDS

Measure	Cost (£)	Product description	Embodied carbon (kgCO ₂ e)	Energy use description	Annual carbon emissions (kgCO ₂ e/year)	Lifetime (years)
Cavity wall	400	Equal parts: blown glass, blown rock and expanded polystyrene	4161	Heating: gas, electricity, oil and coal	-422	25
Loft insulation	300	Equal parts: glass mat and rock mass	113	Heating: gas, electricity, oil and coal	-91	40
Boiler	2000	A new boiler	386	Heating: gas and oil	-447	10
Window	3000	20m ² of new windows tripled glazed	3616	Heating: gas, electricity, oil and coal	-272	20
Door	500	1 new door	275	Heating: gas, electricity, oil and coal	-60	50
Lighting	60	15 new LEDs	380	Electricity	-275	30

TABLE D.1 was calculated using a model created for domestic energy efficiency measures for 2014. This model was based on typical energy savings from common retrofitting energy efficiency measures to a detached, 3 bedroom house based in the UK. The model is reproduced in the following tables. TABLE D. 2 contains a list of sources used to create the model. TABLE D. 3 contains the measurements of a 3 bedroom detached house that were estimated and then used to calculate the amount of energy efficiency measures required. TABLE D. 4 contains the weight of insulation materials needed to insulate a 3 bedroom detached house. TABLE D. 5 contains a summary of the results of calculations based on information contained in the previous tables. The results are a list of measures, their annual carbon emission savings due to energy savings and their embodied energy. This is summarized in TABLE D. 1, which is further amalgamated in Chapter 7.

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TABLE D. 2 REFERENCES FOR DOMESTIC ENERGY EFFICIENCY MEASURES MODEL

Key	
[1]	National Energy Efficiency Data-Framework (NEED) Headline tables - impact measures URN 13D/297
	https://www.gov.uk/government/collections/national-energy-efficiency-data-need-framework
	<i>Accessed on 23/05/2014</i>
[2]	National Insulation Association
	http://www.nia-uk.org/householder/index.php
	<i>Accessed on 23/05/2014</i>
[3]	Energy Saving Trust
	http://www.energysavingtrust.org.uk/
	<i>Accessed on 23/05/2014</i>
[4]	Home Energy Check (by Energy Saving Trust)
	http://hec.est.org.uk/
	<i>Accessed on 23/05/2014</i>
[5]	Insulation Materials Chart - thermal properties and environmental ratings
	http://www.energysavingtrust.org.uk/Publications2/Housing-professionals/Insulation-and-ventilation/Insulation-materials-chart-thermal-properties-and-environmental-ratings
	<i>Accessed on 23/05/2014</i>
[6]	Final Housing Fact File 2011
	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48195/3224-great-britains-housing-energy-fact-file-2011.pdf
	<i>Accessed on 23/05/2014</i>
[7]	English Housing Survey Headline Report 2012-13
	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/284648/English_Housing_Survey_Headline_Report_2012-13.pdf
	<i>Accessed on 23/05/2014</i>
[8]	English housing survey stock report 2008
	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/6703/1750754.pdf
	<i>Accessed on 23/05/2014</i>
[9]	Architect
	<i>Spoken to on 23/05/2014</i>
[10]	Zest Energy Solutions
	http://www.zestenergysolutions.co.uk/solid-wall-insulation.php
	<i>Accessed on 23/05/2014</i>
[11]	Estimate from shop
	<i>Visited 05/06/2014</i>
[12]	Ecoinvent 3.0.1 Database
[13]	Transition Pathways Data

TABLE D. 3 SIZE OF A DETACHED 3 BEDROOMED HOUSE

House	Figure	Units	Reference	Assumptions
Type	Detached		[6]	Although not the most common (17%) they have the most external wall on the whole
Floor size	92	m ²	[7]	
Storeys	2		[8]	
Storey height	3	m	[9]	Rounded from 2.6m + 275mm for floor
Cavity walls	69	%	[7]	
Cavity thickness	0.07	m	[8]	
Surface area (4 external walls)	1104	m ²		Square house (smallest surface area - windows not modelled)
Floor area per story	46	m ²		
Total height	6	m		

TABLE D. 4 INSULATION REQUIRED

Variable	Figure	Units	Reference	Assumptions
Density of polyisocyanurate insulation	32	kg/m ³	[5]	Maximum density
Density of blown glass insulation (installed)	18	kg/m ³	[2]	Maximum density
Density of blown rock insulation (installed)	40	kg/m ³	[2]	Maximum density
Density of expanded polystyrene	12	kg/m ³	[2]	Maximum density
Loft insulation thickness	0.27	m	[3]	
Volume of loft insulation	12.42	m ³		
Common loft insulation	Mineral wool (glass and rock)			
Loft insulation (glass wool)	52.09185278	kg	[11]	
Loft insulation (stone wool)	52.09185278	kg	[11]	
Cavity insulation thickness	0.07	m		
Volume of cavity insulation	77.28	m ³		
Common cavity insulation	EPS Bead (polystyrene bead), Mineral wool (glass and rock)		[2]	
Cavity insulation (expanded polystyrene)	927.36	kg		

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Cavity insulation (glass wool)	1391.04	kg		
Cavity insulation (stone wool)	3091.2	kg		
External insulation thickness	0.12	m	[3]	Maximum of rough guide of thickness
Volume of external insulation	132.48	m ³		
Common cavity insulation	Polyisocyanurate (PIR), expanded polystyrene, mineral wool, phenolic		[10]	
External insulation (expanded polystyrene)	1589.76	kg		
External insulation (glass wool)	2384.64	kg		
External insulation (stone wool)	5299.2	kg		
External insulation (polyisocyanurate)	4239.36	kg		

TABLE D. 5 SUMMARY OF ENERGY EFFICIENCY MEASURES AND THEIR CARBON IMPACT

Measure	Annual carbon emissions (kgCO ₂ eq/year)	Reference	Amount needed (average)	Units required	Life time	Reference	Embodied carbon (kgCO ₂ e)	Reference
Cavity wall insulation (blown glass wool)	-422	[13]	1391.04	kg	25	[3]	3922	[12]
Cavity wall insulation (blown rock wool)	-422	[13]	3091.2	kg	25	[3]	4793	[12]
Cavity wall insulation (expanded polystyrene beads)	-422	[13]	927.36	kg	25	[3]	3768	[12]
Loft insulation	-91	[13]	52	kg	40	[3]	113	[12]
Boiler	-447	[13]	1	p	10	[9]	386	[12]
Solid wall insulation			3378.24	kg				
Window (20m ² of window area) [4]	-272	[13]	20	m ²	20	[3]	3616	[12]
Door (1 external door - size [4][9])	-60	[13]	2	m ²	50	[9]	275	[12]
Lighting (15 light bulbs [3])	-275	[13]	35	lightbulbs	32	[3]	380	[12]

APPENDIX E. BEHAVIOUR CHANGE DATA

TABLE E. 1 INITIAL ROWS AND COLUMNS OF COMBINED LSOA DATASET

country	mlsoa	mname	llsoa	lname	pop	area	house	rucd	run	own	cown	mid	code
England	E02000000	City of Lo	E01000000	City of Lo	1465	13	876	A1	Urban m	60.845	1	28814	4
England	E02000000	City of Lo	E01000000	City of Lo	1436	23	830	A1	Urban m	63.494	1	29450	1
England	E02000000	City of Lo	E01000000	City of Lo	1346	6	817	A1	Urban m	40.024	0	20047	1
England	E02000000	City of Lo	E01000000	City of Lo	985	19	467	A1	Urban m	9.8501	0	12978	0
England	E02000001	Barking &	E01000000	Barking &	1703	15	543	A1	Urban m	63.536	1	16410	1
England	E02000001	Barking &	E01000000	Barking &	1391	20	612	A1	Urban m	19.444	0	5438	0
England	E02000001	Barking &	E01000000	Barking &	1544	20	521	A1	Urban m	16.891	0	3172	0
England	E02000001	Barking &	E01000000	Barking &	1773	13	638	A1	Urban m	40.125	0	8462	0
England	E02000001	Barking &	E01000000	Barking &	2840	35	1103	A1	Urban m	22.575	0	5038	0
England	E02000001	Barking &	E01000000	Barking &	1634	9	457	A1	Urban m	50.328	1	8421	0
England	E02000001	Barking &	E01000000	Barking &	1901	14	698	A1	Urban m	29.656	0	5400	2
England	E02000001	Barking &	E01000000	Barking &	1660	21	650	A1	Urban m	44.615	0	4626	1
England	E02000001	Barking &	E01000000	Barking &	1656	34	638	A1	Urban m	46.552	0	5235	0
England	E02000001	Barking &	E01000000	Barking &	2241	28	836	A1	Urban m	36.483	0	4926	1
England	E02000001	Barking &	E01000000	Barking &	1637	20	626	A1	Urban m	48.562	0	7495	1
England	E02000001	Barking &	E01000000	Barking &	1594	16	609	A1	Urban m	48.112	0	6099	1
England	E02000001	Barking &	E01000000	Barking &	1597	17	612	A1	Urban m	49.346	0	7073	0
England	E0200679	Barking &	E01000000	Barking &	1407	18	504	A1	Urban m	55.952	1	6993	1
England	E0200679	Barking &	E01000000	Barking &	1834	19	650	A1	Urban m	50.462	1	6486	0
England	E02000000	Barking &	E01000000	Barking &	1579	17	593	A1	Urban m	39.292	0	6542	1
England	E02000000	Barking &	E01000000	Barking &	1314	13	474	A1	Urban m	50.633	1	8839	1
England	E02000000	Barking &	E01000000	Barking &	1112	21	500	A1	Urban m	40.8	0	11340	1
England	E02000000	Barking &	E01000000	Barking &	1336	13	456	A1	Urban m	53.289	1	8512	1
England	E02000000	Barking &	E01000000	Barking &	1609	15	629	A1	Urban m	48.013	0	7034	1

APPENDIX F. ACLCA LCA CONFERENCE PAPER

This appendix contains a copy of a conference paper accepted for the American Centre for Life Cycle Assessment's (ACLCA) XIII conference held in Orlando, Florida, October 2013.

Life Cycle Assessment - a more accurate way to measure the carbon footprint of community energy projects?

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Abstract

A community energy project is a project which aims to generate energy for which the community is both responsible for and benefits from. Currently the carbon saving of a community energy project is based on a simple calculation which focuses on the generation phase. However numerous errors in this calculation lead to an underestimate of the carbon saving of such projects by as much as 40%. This underestimation makes the cost per tonne of carbon saved apparently higher than it truly is, and consequently makes this type of project look less attractive than it is to the UK government. Four novel methods, using life cycle assessment (LCA) techniques, to calculate the carbon saving are compared in this paper. It is concluded that a method based on LCA techniques and hourly marginal grid carbon intensity gives the most accurate representation of carbon saving.

Keywords: Community energy project, Carbon footprint, Life cycle assessment, Photovoltaic, Marginal grid

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1 Introduction

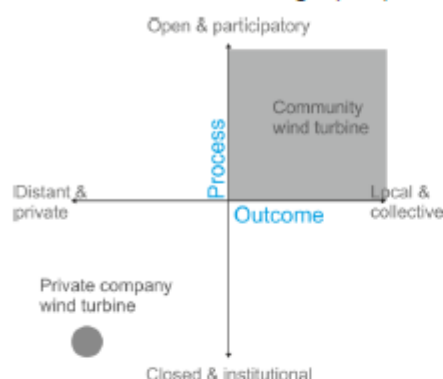
A community energy project is a project which aims to “reduce, manage, generate or purchase energy” for which the community is both responsible for and benefits from (DECC, 2013 p.11). This paper focuses on community energy projects which generate energy.

The majority of communities running community energy projects can be described by their geographical location, for example a village. However there are examples of community energy projects being run by a community which is linked by a common theme, for example office workers (Heiskanen et al., 2010).

Figure 1 illustrates how community energy projects differ from more traditional, privately led energy projects. A community energy project can lie

anywhere within the top, right hand quadrant (Walker and Devine-Wright, 2008). This has led to a diverse range of projects being identified as community energy projects; some projects are developed wholly by the community, whereas others have worked in partnership with other organisations, for example the local authority (DECC, 2013). Consequently there is a range of actors developing community energy projects with different drivers – even individuals within the community may have different reasons for taking part. The main reasons given for taking part in community energy projects are environmental and economic; however reasons range from improving local energy resilience to community empowerment (Databuild Research & Solutions Ltd and Energy Saving Trust, 2013, Ison and Hicks, 2012).

Figure 1 Community energy project vs. privately led energy project; adapted from Walker and Devine-Wright (2008)



1.1 Benefits of community energy projects

Community energy projects which generate energy are a form of distributed generation, and hence have similar benefits over centralised energy, for example by minimising transmission network losses (Allen et al., 2008).

Because the community group acts to pool resources, community energy projects can provide economy of scale unlike that of a citizen acting independently to install energy generation (DECC, 2011c).

Typically community energy projects install renewable or low-carbon generation. Groups approached in this research had installed one or more of the following: wind turbine, photovoltaic panels (PV), hydro turbines and gas fired combined heat and power (CHP) units. This contributes to the decarbonisation of the energy system.

An income stream can be created by selling energy to the National Grid and through schemes designed to reward the generation of low carbon energy, such as feed-in tariffs. This income stream can be used to finance further community energy

projects, create jobs or be invested in an equitable way into the community (Databuild Research & Solutions Ltd and Energy Saving Trust, 2013, DECC, 2012).

Changes in energy behaviour have been reported in some communities, however, others have not been able to find any evidence of this (DECC, 2012, Platt et al., 2011). Participation in community energy projects increases knowledge of energy generation options which can have a positive effect on uptake of energy generation and energy efficiency measures within a community (Rogers et al., 2012, DECC, 2012, Platt et al., 2011). Due to the number of people that participate in community energy projects, this multiplier effect could help transform the energy system to low carbon quicker than other forms of distributed generation. Consequently one useful measurement would be the carbon footprint of community energy projects.

1.2 Carbon footprint of community energy projects

Currently the carbon footprint of a grid connected, community energy project is calculated by multiplying the annual generation by the difference in carbon intensity of the energy generated and that supplied by the National Grid, as shown in Equation 1.

Equation 1 Current method of calculating a grid connected community energy project following assumptions from Energy Share (2012): CI stands for carbon intensity

$$\text{Footprint} \left(\frac{\text{kg}}{\text{y}} \right) = \text{Energy} \left(\frac{\text{kWh}}{\text{y}} \right) \times \left(\text{Project CI} \left(\frac{\text{kg}}{\text{kWh}} \right) - \text{Grid CI} \left(\frac{\text{kg}}{\text{kWh}} \right) \right)$$

The carbon intensity is a measure of how much carbon dioxide equivalent is emitted per kilowatt hour of energy generated. It is

assumed that renewable sources have a carbon intensity of zero (biomass is not included). Energy for the National Grid is generated from a range of fuel sources, each with different carbon intensities. The carbon intensity is assumed to be an average of all these sources (Energy Share, 2012).

1.2.1 Errors in the current method

The current method assumes that no carbon is emitted as a result of renewable sources of generation because the calculation is based around the generation phase. However when the whole life cycle is considered it is clear that carbon is emitted (Rankine et al., 2006). Although current carbon payback period can be low for some technologies, this is based on the carbon intensity of the grid it is assumed to offset (Kawajiri and Genchi, 2012). The carbon intensity of the grid in the UK is set to decrease significantly over the next 25 years, which is within the lifetime of community energy projects installed now (HMG, 2010).

Furthermore this focus on the generation phase of energy neglects the carbon emitted during the whole life cycle of power plants generating grid energy. Carbon emissions from stages such as fuel extraction and processing have been shown to have a significant impact on total carbon emissions associated with power plants (Hammond et al., 2013).

Community groups often publicize the predicted carbon footprint, using predicted energy generation of their energy project in order to entice investors to fund the project (Bristol Energy Coop, 2012, Sheffield Renewables, 2012). However they don't necessarily update this carbon footprint using the actual energy

generation after the project has started (Bristol Energy Coop, 2013). The analysis of a government funded study of community energy projects in the UK was based on theoretical carbon savings of the project rather than actual carbon savings (DECC, 2012).

In the current calculation it is assumed that grid energy is offset by energy generated by a grid connected community energy project, i.e. the National Grid sees community energy projects as a reduction in energy demand. This reduction in energy demand is typically modelled as a reduction in output across all grid power plants; average grid carbon intensity is used (Energy Share, 2012). However there is considerable debate about the accuracy of this assumption (Market Transformation Programme, 2009). This is due to the operation of the UK National Grid, which is made up of two parts: the base load power plants (commonly nuclear) that provide a steady output and marginal power plants (commonly coal and gas) that change output in response to demand change (Hitchin and Pout, 2002).

Therefore when modelling a reduction in demand it would be more accurate to assume that the output from marginal power plants is reduced. Actual carbon savings from PV generation may be lower than a calculation using the average marginal carbon intensity over the year would suggest. This is due to the interaction between the profile of PV generation and the energy demand profile (Burgess et al., 2011).

The problems with the method outlined above are common to all forms of distributed generation. However as discussed community energy projects may be subject to a multiplier effect, where

additional generation and energy efficiency measures are installed and energy behaviour is altered as a consequence of the project. This effect is not currently accounted for in the calculation, yet it could have a significant impact on the cost per tonne of carbon saved of such projects.

The current method therefore, of calculating the carbon footprint of a community energy project is not an accurate measure and may contain both over and underestimations.

1.2.2 Accurate carbon footprints

The UK government have set a target to reduce carbon emissions 80% by 2050 compared to 1990 (HMG, 2008). The ability of different mixes of energy generation to meet this target and how likely it is that these mixes can be attained is currently being assessed, including the impact of community energy projects (Foxon et al., 2010). Although currently in the UK community energy projects account only for a very small proportion of energy generation, there is a potential for them to account for much more. For example, Denmark historically produced 80% of its wind power through community energy projects (Danielsen, 1994). Therefore it is important that the carbon footprint of community energy projects should be accurately represented. Recently the UK government published a report asking for evidence that community energy projects had reduced greenhouse gas emissions (DECC, 2013).

1.2.3 Influencing the carbon footprint

Environmental concerns are a major reason for community groups starting community energy projects (Databuild Research & Solutions Ltd and Energy

Saving Trust, 2013). There are examples of communities wishing to become carbon neutral, or even carbon negative (Ashton Hayes Going Carbon Neutral, 2013, Llangattock Green Valleys, 2013). These communities will need to make choices that reduce the carbon footprint of their energy projects in order to approach these targets.

2 Methodology

Community groups running community energy projects in England and Wales were recruited to a research study, investigating the potential impact on carbon emissions of a large scale increase of community energy projects based on carbon footprints of current projects. Three of the groups are based in the south of Wales. The remaining ten groups are spread widely across England.

Table 1 Methods used to calculate carbon footprints of community energy projects.

Method	Definition
Baseline	Current calculation, predicted energy, average grid carbon intensity
AP1	LCA, predicted energy generation, average grid carbon intensity
AA2	LCA, actual generation, average grid carbon intensity
MyA3	LCA, actual generation, marginal grid carbon intensity (yearly)
MhA4	LCA, actual generation, marginal grid carbon intensity (hourly)

This paper compares four novel methods of calculating the carbon footprint of these projects against the current method, which here is used as a baseline measurement.

The four methods are based on addressing the issues identified with the accuracy of the current measurement and are described in Table 1. The community energy projects presented in this paper are all based on solar generated electricity (PV).

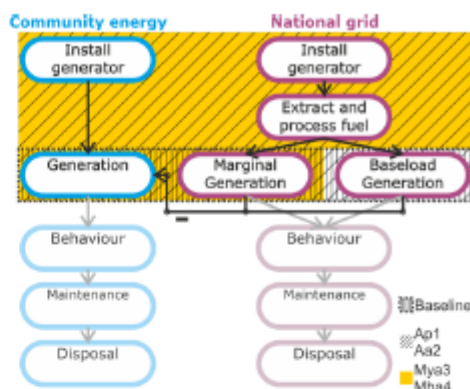
The aim is to develop a calculation which is both accurate and easy to use; some community groups interviewed in this work have struggled to calculate the impact of their project because of a lack of appropriate tools. This calculation should show how the community group can reduce the size of the carbon footprint.

The current method (baseline) is described in the introduction. Values of predicted generation were gathered from websites and share offer documents produced by the community groups. The values may have been predicted by the community group itself or by the installer. In order to reduce the effect of annual variation in average grid carbon intensity, the 5-year rolling average grid carbon intensity for 2010 is used. However there are a number of values published for the average grid carbon intensity; these are intended for different purposes and have different boundary conditions, but are often used interchangeably in the current method. Therefore a range of uncertainty in the baseline calculation has been provided.

The four novel methods of calculating carbon footprints of community energy projects are all based on a life cycle assessment, depicted in Figure 2. This covers material extraction through to installation at the final location and generation over a 25 year life time - the time the panels are under warranty. Maintenance and disposal are not included. Electricity generation is modelled using

system expansion to represent the reduced demand on the National Grid.

Figure 2 System boundaries of each method



Currently around 10% electricity is lost during transmission and distribution (DECC, 2011b). It is assumed that the electricity generated by the project is used in the local area and is therefore subject to negligible transmission or distribution losses. Consequently every unit of community energy generated is assumed to offset 1.1 units of grid generation. The life cycle inventories were analysed using the IPCC 2007 GWP 100a V1.02 method. This method is limited to greenhouse gas emissions.

Interviews with a representative from each community group were used to gather detailed information about the community energy project. This was used to build a life cycle inventory for the project. A monocrystalline panel from the Ecoinvent 2.0 database forms the basis of this inventory. Power plants from the same database were used to create an average grid mix and a marginal grid mix. The average grid mix is modelled on 2009 data published in the Digest of UK energy statistics (DECC, 2011a). The marginal grid mix is based on an analysis of hourly variation of power plant output published

by Cooper et al. (2013). This analysis was averaged to find the yearly average marginal grid mix.

Figures for the actual generation used in three of the methods come from the first full year of generation. A model of the hourly profile of energy generation over a 12 month period was created for the method using hourly marginal grid carbon intensities. This was created using data from the Photovoltaic Geographical Information System (PVGIS) website: irradiance on an inclined plane and temperature for each location, and data from the Sharp ND-195R1S panel data sheet. Equations for calculating power output of PV can be found in Šúri et al. (2007) and Markvart (2000). The magnitude of the created profile was then adjusted, by between 8% and 22% so that the total generation for the first year was within 1% of the actual generation.

2.1 Influencing the carbon footprint

Interviews with community groups suggested that some of them had been concerned with where the panels had been manufactured. Other groups were interested in localism. Therefore an investigation into transport distances of the silicon supply chain was undertaken.

The silicon supply chain for two of the panel manufactures, installed by community groups, was investigated. This supply chain covers metallurgical grade silicon through to installation into each community. Information about each stage of the supply chain was gathered from company websites and from news articles. An assumption was made that only one company supplied the next company in the supply chain, due to time constraints. Where information about the supply chain

was unavailable it was assumed that the company was supplied according to the worldwide output from the preceding stage, published by Dominguez-Ramos et al. (2010).

Transport routes were identified to minimise the amount of road transport required; rail was not considered. It was assumed that ships would travel directly between two ports rather than traveling to lots of intermediate ports as not enough was known about typical shipping routes. Distances travelled on this route was calculated using Google Maps (2013) for road transport and Sea Rates (2013) for port to port distances. The transport routes were modelled using Ecoinvent 2.0 transport processes.

2.2 Case studies

Results for two of the community energy projects are presented in this paper. The characteristics of these projects are in Table 2. Case study 1 is an unusually large project based in the South East of England. Case Study 2 is a typical, small project based in the Midlands of England.

Table 2 Case study characteristics

	Case study 1	Case study 2
Technology	PV	PV
Size	98 kW	3.6 kW
Location	Warehouse	Village hall
Predicted output	92300 kWh per annum	2157 kWh per annum

3 Results & discussion

The percentage difference between the four novel methods examined in this paper and the baseline calculation for both case studies is presented in Table 3. The range of uncertainty in the baseline calculation is 21% to -8%. This is due to the range of average carbon intensities published for different purposes. This is a significant variation in result and suggests the importance of creating a calculation tool or methodology for community groups to use, where this variable is fixed at a suitable level to allow for consistent analysis across the UK.

The difference between the baseline calculation and method AP1 is the use of LCA. Case study 1 shows minimal difference in result between these two methods. Case study 2 however shows a larger difference, with the current method overestimating the carbon savings. This suggests that as the amount of energy generated becomes smaller, the error due to not including carbon emissions outside the generation phase becomes more significant. Due to the banding structure of the feed-in tariff in the UK, community

energy projects are most commonly based on small PV installations (4kW). This suggests that LCA techniques are important to consider when measuring the carbon footprint of such projects.

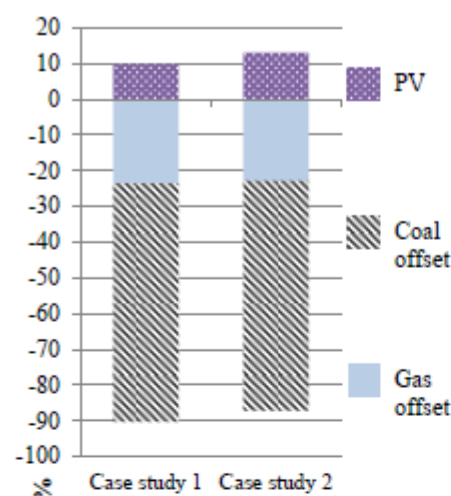
Method AA2 uses the actual energy generation for the first year of operation rather than predicted energy used by AP1 and the baseline methods. Case study 1 again shows minimal difference from this method to the baseline or to AP1; suggesting that methods of energy generation prediction show a good correlation with actual generation.

However case study 2 shows a significant difference because predicted generation was exceeded by actual generation. Due to significant weather variation each year in the UK, generation is also quite variable year on year. It would therefore be prudent to consider the difference between actual and predicted over a number of years. The results here suggest that community groups should update the carbon footprint with actual energy generated.

Table 3 Comparison of methods; the range of uncertainty from the current calculation is +21% to -8%

	Case Study 1		Case Study 2	
	kgCO ₂ e	Difference (%)	kgCO ₂ e	Difference (%)
Baseline	-1199900	0.0	-28041	0.0
AP1	-1178707	1.8	-24088	16
AA2	-1170311	2.5	-33693	-17
MyA3	-1834022	-35	-53992	-48
MhA4	-1547089	-22	-45105	-38

Figure 3 relative contribution from each element of a project



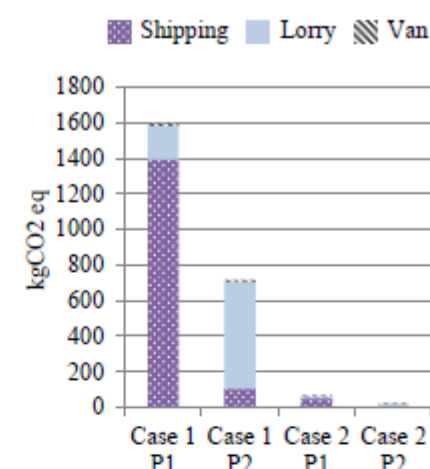
Methods MyA3 and MhA4 use marginal grid mix. There is a significant difference from the methods based on an average grid mix. As it has been shown that PV offsets marginal production it is clear that this should be reflected in the calculation. However it is not clear if similar results would be seen for different technologies.

The difference between MyA3, yearly marginal and MhA4, hourly marginal confirms the findings of Burgess et al. (2011) – a yearly average significantly overestimates the carbon savings of PV. Again this may not be the same for other technologies.

3.1 Analysis of LCA

The relative proportion of carbon emissions associated with PV manufacture and installation, and grid emissions is shown in Figure 3. Although currently the PV itself is only a small proportion, this is likely to increase as the carbon intensity of the grid decreases towards the 2050 target. Therefore the methods used above,

Figure 4 transport carbon footprint for two different manufacturers



currently based on the grid mix now should consider how the grid mix will change over the life time of the projects.

3.1.1 Transport

Transport is responsible for around 3% of the impact of installing a 3kW panel. However community groups can usually influence the choice of manufacturer.

Figure 4 shows how much carbon is produced by transporting silicon up the supply chain for two manufacturers. P2 has between a third and a half of the transport costs of P1.

4 Conclusion and future work

The current method for calculating carbon footprints of community energy projects can underestimate the reduction in carbon emissions by up to 40%. This makes the cost per tonne of carbon saved apparently higher than it truly is, and consequently makes this type of project look less attractive than it is to the UK government.

Therefore a new method of calculating carbon footprints of community energy projects which install PV is suggested: one which is based on the carbon intensity of an hourly marginal grid and uses LCA techniques.

The carbon intensity of the UK grid is likely to decrease in the future. This may affect the difference between the current method and the new method. Therefore the current study should be extended to include the effect of future grid mixes, such as those suggested by Foxon et al. (2010).

A basic investigation of the silicon supply chain suggests that community groups can reduce the carbon footprint of their project by selecting manufacturers with low transport costs. However it is recognised that this is a tiny proportion of total costs and that the grid mix where the factory is located is likely to be more important. Carrying out a LCA and breaking the results into areas that can be easily influenced by the community (such as panel manufacturer) and areas they can influence only indirectly (National Grid mix) will aid community groups reduce their carbon footprint.

The four new methods suggested in this paper could be applied to all distributed PV, regardless of whether installed by a community or an individual. The current boundaries of the LCA need to be expanded to include the reported consequences of community energy projects such as uptake of renewable energy, energy efficiency measures and energy behaviour change. A study of how the energy is used may be required.

At the same time this work could be improved by including uncertainty and sensitivity analysis.

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